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**INTER-ORGANIZATIONAL  
KNOWLEDGE INTEGRATION ON  
CONSTRUCTION PROJECTS: A  
SOCIAL NETWORK APPROACH**

XIMING RUAN

PhD

2007

**Inter-organizational Knowledge Integration on  
Construction Projects: a Social Network Approach**

XIMING RUAN

A thesis submitted in partial fulfilment  
of the requirements of the  
University of Northumbria at Newcastle  
for the degree of  
Doctor of Philosophy

Research undertaken in the School of Built Environment

May 2007



## Declaration

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work.

Name: Ximing Ruan

Signature:

Date: 1<sup>st</sup>/June/2007

# Acknowledgements

This PH.D study is the most challenging journey in my life so far. I can hardly imagine I would have started without invaluable support and guidance.

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In addition, thanks to the supportive industrialists have made this research possible but shall remain anonymous. They supported with the data collection from project teams in construction industry.

## Abstract

This research compares knowledge integration in *competitive* and *collaborative* construction projects in the UK. It begins with the assumption that the most valuable commodity transferred along project supply chains is *knowledge*. It has been suggested that collaborative working methods (such as partnering) may represent a significant improvement in the way project knowledge can be captured and integrated. However, most academic work on knowledge management has concentrated on its integration *within* rather than *between* organizations: the topic is more difficult to address in multi-firm, project-based, and economically fragmented industries (such as construction). The present study focuses upon collaborative working as a vehicle for knowledge integration along the project supply chain. A review of the literature examines how recent approaches to construction organisation have sought to improve performance: these approaches all draw attention to such critical attributes as *trust*, *commitment* and *relationships*, all of which are difficult to measure. In this research, a *social network analysis* approach has been adopted to do this. This is the first time the technique has been put fully to this use in the context of construction projects. Software has been used to help visualize and compare knowledge networks in five projects (representing competitive and collaborative working) and this has provided data for comparison of different working patterns under different procurement systems. The working patterns and knowledge transactions in the two different procurement systems were shown to be different, and there were clear associations between the degree of collaborative working and the nature of social networks encountered. The technique has overcome previous difficulties in measuring certain attributes of collaborative working; has provided a way of benchmarking the differences in the way that competitive and collaborative working facilitate project knowledge integration; and represents a useful and novel way of analysing organizational behaviour in projects. It has explained *why* and *how* partnering and collaborative working can bring certain advantages.

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# Chapter 1 Introduction

## 1.1 Background, Collaborative working in the knowledge economy era

The importance of Knowledge Management has attracted lots of discussions both in academic and practice. Lots of schools of thought approach Knowledge Management from different viewpoints, such as organizational learning and Knowledge Management, Knowledge Management and competitive advantages, Knowledge Management and human resources management. From managerial viewpoint in practice, organizational knowledge is becoming the most important resource within business organizations. According to Drucker (1992), land, labour and capital – the classical factors of production – have become secondary to knowledge as the primary resources for the new economy. “Knowledge has been called the only meaningful economic resource of the post-capitalist or knowledge society” (Drucker 1993). Some even assert that the most valuable added on commodity is not physical resources but professional knowledge by which commodities serve customers well (Marks and Patterson, 1992; Lowendahl *et al*, 2001). This discussion has spread to almost all industrial disciplines, including that of construction project management.

Construction projects have been characterised as complicated processes (Shirazi *et al.*, 1996), in a turbulent environment (Groak, 1994), with unpredictable working schemes (Rasdorf and Abudayyeh, 1991), unique project designs (Jaafari, 1996) and temporary organized teams (Cherns and Bryant 1984, Lundin & Soderholm 1994). All of these characteristics make special challenges to Knowledge Management applications in the construction industry. When Knowledge Management first extended into construction

project disciplines, scholars started by discussing how to manage knowledge *within* particular projects, considering the challenges from those characteristics (see, for example Egbu 2001; Egbu & Botterill, 2002; Lee *et al.*, 2005) Attention later turned to how to manage knowledge *across* projects.

The project is a main unit of management for most construction business (Harris and McCaffer, 2001). This characteristic makes Knowledge Management in the construction industry somewhat unique, because, amongst other things, of its natural tendency to 'knowledge leakage' (Matusik and Hill, 1998). The basic problem is that, although people are inspired to make innovative solutions in the individual project scenario, the knowledge involved is normally lost, or, at best, stored personally after that project, rather than be stored in and diffused across a whole organization or organisations. Project-based staff will regularly work hard at solutions to a problem that their colleagues have actually worked out somewhere else, on another project. Such Knowledge Management problems in the construction industry have already been noted and explored both in academia and practice (see for example, Carrillo *et al* 2000; Egbu 2001; Chan *et al.* 2006).

However, much of this work is directed at managing knowledge *within* organizations, as knowledge is viewed as valuable resource even intellectual asset. The originality of the present study lies in its proposition that knowledge should be and could be managed better in the construction industry with the growth in popularity of collaborative systems of procurement that are broadly described as *partnering*. If we accept that knowledge, just like other commodities, adds value to a product, and that the most value-added input along the product Supply Chain is knowledge, then the study of Knowledge Management *between* organisations within project Supply Chains will provide a meaningful insight for businessmen and academics for further improving the industry's product.

Within the strategic partnering arrangements that are allegedly becoming popular in

the construction industry (Balow, 1996 & 1998, Bresnen and Marshall 2000), people are assumed to display collaborative and supportive behaviours, which would, perhaps include contributing their knowledge and expertise to a common cause. If, in the UK, construction is changing from a competitive working environment to a more collaborative one, the outcome for knowledge may be that it becomes a resource for collaborative advantage, rather than one for competitive advantage. In fact, while the concept of Supply Chain integration and collaboration is gaining increased acceptance in the UK construction industry, the project participants are realising that the sharing of knowledge and information is one of the key elements of success (McDermott *et al.* 2005).

The research tool that will be employed for this study will be Social Network Analysis (Wasserman and Faust, 1994; McCarty 2001; Carrington *et al.* 2005; Hanneman and Riddle; 2005). It is proposed, not only that social networks themselves act as a vehicle for knowledge (e.g. by facilitating its transfer) but that the analysis of these networks, in different situations, may act as an informative indicator of the process by which project knowledge is created, shared, diffused, stored or, alternatively, lost. By analysing project-based social networks operating under different procurement systems, knowledge contribution and information exchange activities to support collaborative working can be identified. These will then be compared, and any differences of working patterns under different procurement systems may be identified.

There are a number of different aspects, during the life of a project, upon which decisions are taken, solutions are devised, and knowledge could be said to be 'created'. All of these aspects would be possible candidates for such an analysis to be carried out. However, the focal point of the present study will be the enduring problem of 'design changes'. This issue has long been recognised by writers as possibly the major problem faced by the project team (Cox, 1999). On the other hand, design changes maybe the very issue that prompts most creative solutions from within

the team.

## **1.2 Social Network Analysis approach**

Social Network Analysis provides a method to understand informal networks within and between organizations and manage the informal networks systematically (Cross and Prusak, 2002). Social capital makes an organization, or any collaborative group, more than a collection of individuals' intent on achieving their own private purposes. Social capital bridges the space between people. Its characteristic elements and indicators include high levels of trust, robust personal networks and vibrant communities, shared understandings, and a sense of equitable participation in a joint enterprise—all things that draw individuals together into a group. This kind of connection supports collaboration, commitment, ready access to knowledge and talent, and coherent organizational behaviour (Cohen and Prusak, 2001 p. 4).

The key difference that distinguishes Social Network Analysis from other analysis and management methods is that Social Network Analysis draw attention to informal network in working place. Basically, Social Network Analysis is used to measure and visualize relationships and flows between people, groups, organizations, computers or other information/knowledge processing entities.

McCarty (2001) explains that Social Network Analysis (SNA) is both a theoretical perspective and a set of methods. In terms of theory, SNA extends and complements traditional social science by focusing on the causes and consequences of relations between people and among sets of people rather than on the features of individuals. In terms of method, SNA focuses on the measurement of relationships between people. In use of relational concepts, the following are important:

- Actors and their actions are viewed as interdependent (rather than independent)



autonomous units. Relational ties (linkages) between actors are channels for transfer or "flow" of resources (either material or nonmaterial)

- Network models focusing on individuals view the network structural environment as providing opportunities for or constraints on individual action
- Network models conceptualize structure (social, economic, political, and so forth) as lasting patterns of relations among actors (Wasserman and Faust, 1994)

Social Network Analysis for Knowledge Management focuses on knowledge exchange, value of information, and how well people know each other's knowledge and skills. In today's fast growing knowledge era, know-who is more important than know-how as knowledge is developing diversely, every subject covers a large amount of expertise.

## **1.3 Research development**

The previous two sections have briefly set the context within which this research will explore features of Knowledge Management in competitive and collaborative working scenarios, using a social network approach. This will involve the following steps:

- Review the literature of
  1. Knowledge Management,
  2. contemporary construction procurement systems, and
  3. the applications of social networks analysis;
- From an analysis of the literature on knowledge and the UK construction management, to make a number of propositions about their interconnection in the context of construction projects;
- Develop a research framework grounded in the literature supporting empirical research, and design reliable and valid data collection methods to test these

propositions;

- Present, analyse and discuss the data collected;
- Explore the implications that have arisen in progressing the research and in the light of this, re-appraise the research aims and objectives;
- Present conclusions, and discuss their contribution; comment on the limitations of the work and on ways in which it could be developed.

In knowledge economy era, the most value added along Supply Chain is knowledge rather than physical product; clients mainly pay for professional knowledge underlying services rather than the physical commodity delivered. From this viewpoint, collaborative working is, in essence, a knowledge collaboration and integration process. Furthermore, as Knowledge Management (KM) has evolved from KM *within* organizations to KM *between* organizations, it is increasingly a matter of managing collaborative working for knowledge contribution along supply chains. In other words, it has evolved into collaborative working for knowledge integration. Therefore, the network analysis of knowledge networks and business transaction networks will demonstrate different patterns of working relationships and knowledge transactions. The management of Knowledge Networks, therefore, become an essential element of this research.

The aim of this research is to compare knowledge integration in two different working environments: namely, a collaborative environment and a more traditional, competitive one.

In order to achieve this aim, the research work used a Social Network approach. Accordingly, the following objectives were set

- A description of the present application of Social Network Theory, competitive/collaborative working and Knowledge Management in a construction project context.

- A comparison of different social network structures within two different procurement systems, which are competitive and collaborative procurement systems, to what extent and measures these two networks differ. This research proposes that a project with a collaborative partnering relationship would create different networks' structures from a non-partnering one. This will examine that how some social network attributes vary in different procurement systems. Varied network structure and attributes will be used to explain different knowledge transaction activities in the project process. The comparison will display the extent and under what conditions collaborative working could lead to certain advantages and how to reinforce these issues to support the advantages. The social structural conditions which support collaborative working and knowledge integration will reduce non-collaborative behaviour, while fostering cooperation and support towards others.
- An investigation of knowledge integration features in two procurement systems from a Social Network Analysis perspective. This will be achieved by analysing individual organizations in the measures of centrality and density. This exploration will identify benefits and constraints of Knowledge Management in collaborative working within an inter-organizational extent from a Social Network Analysis perspective, and to conclude the key business characteristics of Knowledge Management within strategic partners supporting collaborative working in construction projects.
- A description of the role of social networks in terms of knowledge integration in collaborative working. This will be achieved by the following:
  1. Establishment of key knowledge roles in collaborative working partners, to ensure that knowledge reaches all the parties of a project that need them.
  2. Mapping existing pathways and patterns for knowledge flow between organisations in collaborative working projects.

The analysis above will answer the following two questions which are useful for managerial concerns:

1. When Social Network Analysis is applied to a construction project to produce meaningful insights, how can a knowledge supporting network be structured to produce inter-organizational virtual knowledge integration?

As Knowledge Management is based on information network but has more contents such as tacit dimension, this research will start from informal working relationship analysis by Social Network Analysis. This analysis provides inter-organizational network relationships in construction project process. The presentation of interactive knowledge exchange channel in construction process will provide insight of knowledge integration network in construction project. The comparisons of different knowledge network between collaborative working and competitive working are to be concluded in the end.

2. From a Social Network perspective, how does the collaborative working pattern facilitate knowledge integration within project participants?

This will be measured by:

- i. Centrality: the extent to which a network is organized around one or more central people. In this research, degree centrality, closeness centrality and flow betweenness centrality is to be measured
- ii. Density: the percentage of connections that exist out of the total possible that could exist. This explanation leads to understanding of cohesive or fragmentation in different procurement systems.
- iii. Core/periphery measurement: The core-periphery structure is an ideal typical pattern that divides both the rows and the columns into two classes. The core is a high-density block; the other block the periphery is a low-density block. Actors in the core are able to coordinate their actions; those in the periphery are not. As a consequence, actors in the core are at a structural advantage in exchange relations with actors in the periphery. The core/periphery patterns in two procurement systems will present the different social network connections in the needs of knowledge supporting activities.

These measures are to identify gaps and establish which linkages can be made to

facilitate better knowledge sharing within strategic partners in collaborative working

From a Social Network perspective, there are virtual knowledge supporting networks in construction projects. This virtual knowledge supporting network is developed mainly on committed relationships rather than contractual determinations. This research takes a design change (a variation under the contract) as the focal point of the empirical study, on the basis that it is here that knowledge integration activities display intensively.

The knowledge supporting networks in project process are different in collaborative/competitive procurement systems. The knowledge supporting network is based on informal working relationships to ensure tacit knowledge exchange and contribution in project process and different procurement systems create different working patterns, which could be analysed by Social Network Analysis.

From a Social Network Analysis perspective, the roles and positions different organizations play changes in different procurement systems and this can be revealed by Social Network Analysis. The analysis will identify “core actors” and “peripheral actors” in the working process of two procurement systems. The roles and positions that functional teams play in two procurement systems may change accordingly.

The analysis and comparison of examples of two different procurement systems using a Social Network Analysis viewpoint will provide an insight to conclude the reasons why and how in certain conditions, collaborative working generates advantages. This analysis and comparison will provide answers to how knowledge flow and integration could be improved in projects.

## 1.4 Contributions

The contribution to existing knowledge will be made in two parts, namely academic and operational.

The academic contributions made are:

- A critical review of research on Knowledge Management, Social Network Analysis management methods and procurement systems in relation to construction project;
- Development of research framework appropriate to investigating the role that social networking plays in the collaborative working in terms of Knowledge Management;
- Review and analysis of literature on research methodologies and the development of a research design suitable for empirical research;
- Testing the research design and evaluating its effectiveness
- Synthesis of research findings and analysis to determine key Knowledge Management issues affecting collaborative working in strategic partnering
- Identification of potential research areas

The operational contributions are:

- Descriptive case studies illustrating how Knowledge Management supports collaborative working within strategic partnerships
- Guidelines for the deployment of social network theory in analyzing Knowledge Management and information exchange within collaborative working partners
- Identification of opportunities for Knowledge Management to provide greater support to collaborative working

## **1.5 Structure of the thesis**

This thesis is structured in three parts.

The first part introduces the topic and presents the background of this research. After topic analysis, the relevant literature will be reviewed in order to draw a research framework along with selection of research methodology, this part concludes with a research design

The second part of the thesis conducts case studies in a descriptive style and format. Five cases will be tested, based on the research framework and research design developed in first part.

The final part of the thesis synthesizes findings across all the case studies and analyses critical factors revealed. The results of the research project are summarised and conclusions are drawn upon the contribution and recommendations.

## **Chapter 2 Knowledge Management, basic concepts and models**

We are in the midst of an economic transition from an era of competitive advantage based on information to one based on knowledge creation (Lang, 2001). With rare exceptions, the productivity of a modern corporation or nation lies more in its intellectual and systems capabilities than in its hard assets (Quinn *et al.*, 1996). It is *knowledge* – which, as Malhotra (1998) suggests, serves as a “rich carrier of human interpretation for potential action” – that has risen to prominence as the currency of the global economy as we begin the twenty-first century. Townley (1994:16) even asserts that ‘knowledge is not secondary, detached and independent, a source of illumination, but is integral to the system of administration and governance which it helps establish’.

Knowledge Management is attracting more and more attention in academic fields in recent years in many disciplines including project management. Maybe it could be argued that a knowledge era has followed the agriculture economy, industrial economy and information economy (Davenport, 1995). Not surprisingly, knowledge is vital for company to survive in business competition and therefore knowledge is considered as an important asset which needs management.

This chapter is to review some of the basic concepts and Knowledge Management models within business organizations and the construction industry. This chapter starts discussing knowledge from basic concepts such as data and information, which are regard as the basis for discussing knowledge. And then, the review moves to relevant concepts and knowledge taxonomy which include the debate of tacit and explicit knowledge, and working definitions for this research at the end. This chapter focuses on Knowledge Management within individual organizations. The methods of



managing knowledge contribution activities between organizations will be discussed in Chapter 3 after the discussion of business network and networking.

## **2.1 Knowledge Management, an historic overview**

### **2.1.1 Development of Knowledge Management research**

Hearn and Bradier (2002) conclude there are three generations in Knowledge Management research. They suggest that first generation of Knowledge Management is information portals which means tools and methodologies integrating to large or lesser extent information necessary for back and front office processes in organizations. A reflection of early movements by information systems suppliers into Knowledge Management, suggested that such first generation Knowledge Management approaches suffered from a lack of a holistic framework or people or community-centered approach. Since 1999, Knowledge Management has been moving away from this arena towards a more holistic treatment of primarily tacit knowledge in organizations.

The second generation Knowledge Management is from knowledge processes to business processes – tools and methodologies linking knowledge and business processes including assessment or measurement type projects and collaboration and innovation spaces.

The third generation of Knowledge Management connects knowledge and innovation ecologies – tools, methodologies and good practices which identify contextual barriers and enablers of absorptive and innovative capacities of organizations and attempt to replicate co-creation abilities across the enterprise or network which

focuses on human-centered Knowledge Management and networks and working groups.

Similarly, Griggs *et al.*, (2002) provide a brief chronology of Knowledge Management efforts influenced by technology revolution, replicated in the following table:

Period	Orientation
1960s	Data-centric, IT orientation (Knowledge captured in forms, reports and databases)
1970s	Information-centric, MIS orientation (Data converted to information via ad hoc database queries, graphics and presentations)
1980s	Decision Support System orientation (Knowledge encapsulated in models and simulations; more sophisticated statistical applications)
1990s	Web-based knowledge support (Capture, organization and dissemination of knowledge using web)
2000s	Advanced Computation Techniques (Convert information to knowledge using concept clustering, linking, searching, ontologies, multimedia, AI and others)

*Table 2.1 Knowledge Management development orientation*

(Adopted from Griggs *et al.*, 2002)

From a comprehensive review of Knowledge Management development, it is obvious that the general trend of Knowledge Management research is developing toward being human centered across various organizations in different disciplines. Davenport (1995) asserts that "the most dramatic improvements in Knowledge Management capability in the next ten years will be human and managerial". Although Knowledge Management in project-based construction process is not new, it still need more research. Knowledge is a vital resource in project-based industries such as aerospace, construction, shipbuilding and software. If managed effectively, knowledge can be used to reduce project time, improve quality and customer satisfaction. (Love *et al.*, 2003). Not surprisingly, Knowledge Management research has extended into project management in the construction industry (Busby, 1999; Egbu 2001; Egbu & Botterill, 2002; Cooper, Lyneis, & Bryan, 2002, Kamara, Anumba, & Carillo, 2002). In order to clarify the concepts used this research, the following section aims to

discuss definitions of data, information and knowledge and their relationships.

## **2.1.2 Data, information and knowledge**

### **2.1.2.1 Relationships of three terms**

In order to build this research on a solid foundation, the clarification of the three terms is very important. There are still ambiguities in practice when talking about Knowledge Management due to the lack of proper definitions of the three terms. For instance, sometimes Knowledge Management is used as a new label for information management.

For a not well defined term, knowledge has been used broadly. In the view of philosophy, two major traditional streams of thought about knowledge exist: rationalist and empiricists. Rationalists have sought a definite foundation of knowledge, whereas empiricists sought to find a basis for knowledge in sense experience.

Rational theories of knowledge assert that absolutely certain knowledge can be discovered by employing certain procedures of reason alone. These theories claim that certain knowledge can not be found in experience but only in the realm of the mind. (Popkin and Stroll, 1993).

Empiricism is the theory that all knowledge is derived from sense-experience. Russell (1948, p516) defines empiricism as the assertion that 'all synthetic knowledge is based on experience'

Defining data, information, and knowledge is difficult. Only through external means or from a user's perspectives, can one distinguish between data, information, and knowledge. In general, data is considered as raw facts, information is regarded as an organised set of data, and knowledge is perceived as meaningful information (Bhatt, 2001).

Basically, knowledge refers to an observer's distinction of "objects" through which they bring forth from the background of experience a coherent and self-consistent set of coordinated actions (Zeleny, 1987). Through the process of distinction, individual pieces of data and information become connected with one another in a network of relations. Knowledge then is contained in the overall organisational pattern of the network and not in any of the components. Knowledge is more than information. Information is data organised into meaningful patterns. Information is transformed into knowledge when a person reads, understands, interprets and applies the information to a specific work function (Lee and Yang, 2000). Information is a component part but not the whole of knowledge (Machlup, 1982). Information has little value and will not become knowledge until it is processed by the human mind (Ash, 1998). Knowledge itself is a much more all-encompassing term that incorporates the concept of beliefs based on information (Dretske, 1981). It also depends on the commitment and understanding of the individual holding these beliefs, which are affected by people's interaction and the development of judgement, behaviour and attitude (Berger and Luckmann, 1967).

Kogut and Zander (1992), define information as "knowledge which can be transmitted without loss of integrity" (p. 20), thus suggesting that information is one form of knowledge, which did not sufficiently separate information from knowledge.

Nonaka (1997) regards information as passive, but knowledge is committed and active. Nonaka contends that information is not worried about truth, goodness, and beauty; but knowledge aspires to some higher object, to something universal.

McDermott (1999) describes six characteristics of knowledge that distinguish it from information:

- Knowledge is a human act.
- Knowledge is the residue of thinking.
- Knowledge is created in the present moment.
- Knowledge belongs to communities.
- Knowledge circulates through communities in many ways.
- New knowledge is created at the boundaries of old (p. 105).

However, these six characteristics are loosely connected and they cannot form a firm foundation for managing knowledge. Knowledge cannot be defined clearly by these six characteristics.

Drucker (1993) considers that all organizations need data and in fact, some industries are heavily dependent on it. Data describes only a part of what happened; it provides no judgement or interpretation and no sustainable basis of action. It says nothing about its own importance or irrelevance. Data by itself has little relevance or purpose, but data is important to organizations because it is essential raw material for the creation of information.

Davenport and Prusak (1998) provides working definitions of data, information and knowledge from an organizational management perspective as the following:

- Data: a set of discrete, objective facts about events. In an organizational context, data is most usefully described as structured records of transactions and is usually stored in information systems.
- Information are messages, which are usually in the form of documents or an audible communication. As a message, information has a sender and receiver, it moves around an organization through hard and soft networks.
- Knowledge, derives from information as information derives from data. However,

if information is to become knowledge, humans must do all the work. The transformation happens by answering the following questions:

- i. Comparison: how does information about this situation compare to other situations we have known?
- ii. Consequences: what implications does the information have for decisions and actions?
- iii. Connections: how does this bit of knowledge relate to others?
- iv. Conversation: what do other people think about this information?

Davenport and Prusak (1998) consider that data can be found in records or transactions, information can be found in messages; knowledge can be obtained individuals or groups of knowers, or sometimes in organizational processes and procedures. Information has relevance, purpose, and meaning. They describe the transformation of data into information in the following steps:

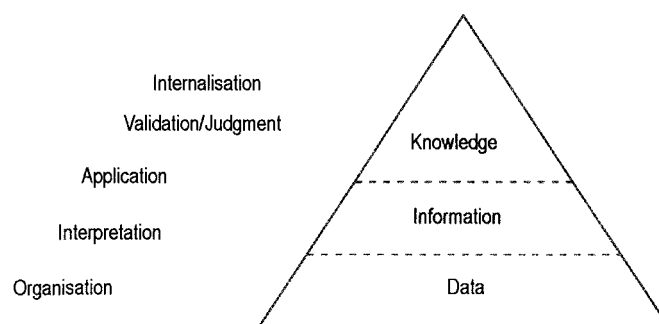
- Contextualized: the purpose the data were gathered is specified.
- Categorized: the data are divided into key subsets
- Calculated: data may have been analyzed mathematically or statistically.
- Corrected: errors have been removed from the data.
- Condensed: data may have been summarized in more concise forms.

Also Davenport and Prusak (1998) stress that computers or information technology can help to add value and transform data into information, but humans must be involved with categorization, calculation, and condensing data.

Based on the definitions of data and information, Davenport and Prusak suggest knowledge as a fluid of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of the knowers. In organizations, it often becomes embedded not only in the documents or repositories but also in organizational procedures, processes, practices, and norms. (1998, p 5)

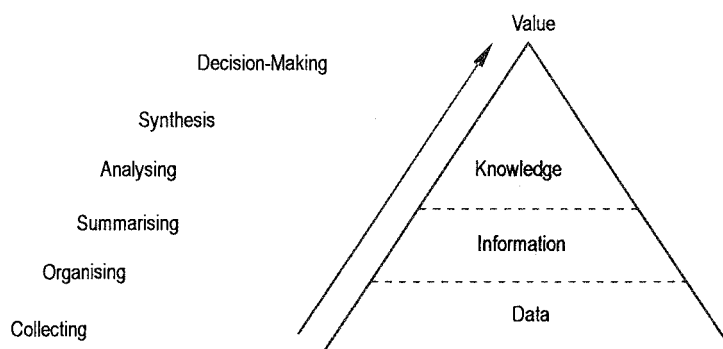
The working definitions suggested by Davenport and Prusak are useful to distinguish the three terms, but in daily practice, sometimes it is hard to determine specified phrase or record as data, information, or knowledge. For example, a short statement contains certain figures, could be information but also could be knowledge when it is interpreted by in meaningful way. This situation becomes more complex in the fast development of multimedia age.

Frey (2001) discusses the relationship between data, information and knowledge. He regards that data must be converted into information, which is transformed into knowledge, which in turn must grow into authentic understanding, as depicted in Figure 2.1 and 2.2 below.



*Figure 2.1 Data, information and Knowledge*

(Adopted from Frey, 2001)



*Figure 2.2 Value-added knowledge processes*

(Adopted from Frey, 2001)

But there are lots of gaps in this structure. Frey doesn't explain in detail how data are transferred into information and in turn to knowledge, Frey merely points out that data should be organized and summarized for being meaningful information, information should be analysed to be knowledge. Frey does not explain in practice how to organize the transforming process and doesn't say whether transforming is a one step process or a micro circle in every step. In the meantime, in this structure Frey thinks the transforming process is one way--from data to information and to knowledge. He does not explain if knowledge could be transformed to information and back to data.

Martensson (2000) also explains the relationships of the three terms. Based on Infield's work (1997), Martensson (2000) suggests that although information is not knowledge, it is an important component of knowledge. Basic raw facts and data are organised and structured to produce general information. The next stage is to produce contextual information by organising and filtering this general information to meet the requirements of a specific community of users. And then, the contextual information are transformed into knowledge by human being. This transformation process is affected by individuals' attributes such as experiences, attitudes, working environment.

Also from other's works (Davenport *et al.*, 1998; Kirchner, 1997; Frappaolo, 1997; Allee 1997; Sveiby (1997), Martensson (2000) concludes that knowledge is developed from information which also includes experience, context, interpretation, reflection, and perspective. Therefore, knowledge should be studied in context. Also Martensson (2000) acknowledges that knowledge would be valuable when it is used for decisions and acts.

Further more, different kinds of knowledge are distinguishable including *know-what*, *know-why*, *know-how* and *know-who* (OECD, 1996), which are described as follows:

- *Know-what* represents an accumulation of facts, and is closest to information, in that it can be broken down into bits.



- *Know-why* refers to scientific knowledge of the principles and laws of nature, that underlies technological development and product and process advances.
- *Know-how* suggests the skills of capability to do something, typical of the knowledge developed and kept within a company, and the reason for the formation of industrial networks to enable firms to share and combine elements of know-how.
- *Know-who* involves information about who knows what, and who knows how to do what, and implies the formation of special social relationships to secure access to experts, which is particularly necessary in response to acceleration in the rate of change.

From an information technical perspective, Bohn (1994, p61) makes similar distinction in analysing knowledge. Whilst data comes from sensors and reports the 'measured level of some variable', information is 'data that have been organised or given structure—that is, place in context—and thus endowed with meaning' (p62). Knowledge is argued to be more prophetic. Knowledge 'allows the making of predictions, causal associations, or prescriptive decisions about what to do' (Bohn, 1994, p.62; Jaikumar and Bohn, 1986). This differentiation between data, information, and knowledge is uncertain, confusing, and ambiguous. It is a differentiation that much philosophy ignores entirely (Russell 1948; Machlup, 1982). One difficulty is that data and information are not knowledge, but are hierarchically subordinate to knowledge. Another difficulty is the unstated assumption that there is a linear process transforming data into information and then into knowledge (Earl, 1994). Whilst a useful taxonomy from a traditional information system perspective, it is not grounded in theory and can only be confusing to other academic disciplines.

Other authors also define the differences between data, information and knowledge which are listed below.

Author(s)	Data	Information	Knowledge
Wiig, 1993 -		Facts organised to describe a situation or condition	Truths, beliefs, perspectives, judgements, know-how and methodologies
Nonaka & - Takeuchi, 1995		A flow of meaningful messages	Commitments and beliefs created from these messages
Spek & Spijkervet, 1997	Not yet interpreted symbols	Data with meaning	The ability to assign meaning
Davenport, 1997	Simple observations	Data with relevance and purpose	Valuable information from the human mind
Davenport & Prusak, 1998	A set of discrete facts	A message meant to change the receiver's perception	Experience, values, insights, and contextual information
Quigley & Debons, 1999	Text that does not answer questions to a particular problem	Text that answers the questions who, when, what, or where	Text that answers the questions why or how
Choo, Dettlor, & Turnbull, 2000	Facts and messages	Data vested with meaning	Justified, true beliefs

*Table 2.2 definitions of data, information and knowledge*

Although the definitions of the three terms are still ambiguous, it is generally agreed that there is a hierarchical structure of data, information and knowledge. Normally knowledge is on the highest level of the hierarchy and the data is a starting level. The structure suggests data could be converted into information, and in turn converts into knowledge, which is the most useful asset for organization.

To summarize the discussion above, there are considerable philosophical debates about data, information and knowledge. Knowledge is a deeper concept than information, which refers to the most accessible elements of the know-what and know-why components. Some types of knowledge come closest to being market commodities, while other types of knowledge, particularly know-how and know-who, are more tacit and difficult to measure, but often are the most valuable to possess (Clarke and Rollo, 2001).

### **2.1.2.2 Knowledge dimensions and definition**

Following the discussion of relationships between data, information and knowledge, this section focuses on discussion of knowledge. In discussing knowledge, some relevant concepts are introduced which define knowledge dimensions. The examination of knowledge dimensions will help to establish a context for understanding knowledge definition.

According to previous work, knowledge has a number of dimensions. In general, there are two distinct types of knowledge which are fundamental to the understanding of knowledge; these are explicit or articulated knowledge and implicit or tacit knowledge. The phrase “tacit knowledge” was firstly used by Polanyi (1958, 1962), and then later widely quoted, especially after Nonaka’s development about tacit knowledge and explicit knowledge. Tacit knowledge implies that certain knowledge is hard to capture and transfer, and this concept is developed by some authors which are listed below.

Nonaka (1994) distinguishes between tacit and explicit knowledge; Nonaka and Takeuchi (1995) describe knowledge as fundamentally existing in two forms: tacit knowledge and explicit knowledge. Explicit knowledge encompasses tools, techniques, and methodologies, which lead to best practices. Tacit knowledge comprises experience, know-how, and competencies or skills. Nonaka (1997) thinks that tacit knowledge corresponds to analogue data, and explicit knowledge to digital data. He further comments that digitalization is important; but people must interact, and their interaction is analogue, not digital. Bonora and Revang(1993) claim that tacit knowledge is a human asset, while explicit knowledge is part of an organization’s resources.

Allee (1997a) also adopts the concepts of tacit knowledge and explicit knowledge.

She describes tacit knowledge as personal, context-specific knowledge that resides in individuals. Explicit knowledge is more formal codified knowledge conveyed from one person to another in systematic ways. While tacit knowledge relies on experience, hunches, and insights, explicit knowledge is conveyed through documents, images and other deliberate communication processes.

However, knowledge could be evaluated from the following aspects:

- *Knowledge as an object.* Knowledge may be viewed as an object or thing (Allee 1997a, *the knowledge evolution*) this view affects how one would manage knowledge. Thinking of knowledge as an object leads management to focus on databases or other storage devices. From this view come terms such as knowledge transfer: knowledge can be passed among individuals. This view emphasizes identifying, collecting, organizing, and storing knowledge.
- *Knowledge as process.* Viewing knowledge as a process emphasizes the dynamic aspects of knowledge, such as sharing, creating, learning, and communicating. According to Allee(1997a), Polanyi describes knowledge as *a process of knowing*. Similarly, Osler (1906) in his book *the Principles and the Practice of Medicine*, considers that there is no skill; there is only method.
- *Knowledge as values and beliefs.* People's values and beliefs have a powerful impact on organizational knowledge. Organizations are made up of people whose values and beliefs inescapably influence their thoughts and actions. Values and beliefs are integral to knowledge, determining large parts of what the knowers see, absorb, and conclude from their observations (Davenport and Prusak, 1998). Nonaka and Takeuchi (1995) compare knowledge and information management and note that knowledge, unlike information, is about beliefs and commitment. This viewpoint conveys the important enabling factors of organizational culture and leadership in the knowledge-management arena.
- *Knowledge as a complex system.* Knowledge maybe viewed as a complex, self

organizing system, which requires a proper environment (Allee, 1997a). Allee (1997a) perceives the organizational environment as a garden in which knowledge grows. This view point emphasizes culture, leadership, behaviours, norms, and supporting technology as important enablers of Knowledge Management.

Also, the following dimensions should be noticed from basic distinctions between explicit and tacit knowledge.

### **Explicit versus tacit knowledge**

Tacit knowledge is difficult to articulate and is mostly heuristic, subjective and internalised. It is learnt through practical examples, experiences and practice. In contrast, explicit knowledge can be formally represented and communicated through language (Faulkner & Senker, 1995).

According to Clancey (1989), knowledge is dynamic and represents a capacity to act and adapt within a changing environment. Although explicit knowledge can be represented, it cannot be exhaustively detailed in statements of belief or prescriptions for behaving. Polanyi (1966) has pointed out that tacit and explicit knowledge are not sharply divided. While tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied. Hence, all knowledge is either tacit or rooted in tacit knowledge.

Codified knowledge is the knowledge which is recorded in an explicit format, in text, drawing or speech. It is largely found in manuals, drawings, record books and computers. Although it is termed as knowledge, it is in fact encoded data and information. Only with human reasoning can this information be made sense of and effectively utilized. Uncodified knowledge, on the other hand, represents the tacit knowledge which resides in individual and groups.

### **Explicit & collective knowledge**

Explicit and collective knowledge is the knowledge a community can exploit (Baumard, 1996). Spender (1996) suggests that knowledge shared by a community should be considered “objectified knowledge”.

In an organization, patents, written rules and procedures, organizational charts, and managing decisions that are known by the whole organization (such as those disseminated through formal memoranda) are all part of the explicit and collective body of knowledge. Patents, for instance, are the written articulation of the technical know-how of the firm (Teece, 1987).

Rules that are informal and ephemeral can become permanent and explicit through ‘institutionalisation’ (DiMaggio & Powell, 1983).

### **Explicit & individual knowledge**

Every part of our knowledge that becomes conscious to us, becomes part of our individual explicit knowledge (Baumard, 1996). This knowledge guides our execution of tasks by providing certain rules of thumb. However, this knowledge requires the individual’s own tacit understanding to interpret or apply it effectively.

### **Tacit & collective knowledge**

This is knowledge which is tacit but shared among a group of individuals. The tacit circulation of knowledge helps organizations to solve problems that they cannot make explicit (Baumard, 1996).

Tacit and explicit knowledge can also be a guarantee of organizational safety (Baumard, 1996). The “collective mind” of flight deck operators (Weick & Roberts,

1993) permits highly complex organizational tasks to be achieved with very few accidents. This “organizational mentality” or “organization mind” (Sandelands & Stablein, 1987) relies upon a tacit understanding that does not necessitate explication.

### **Tacit & individual knowledge**

Polanyi (1966) declares ‘we know more than we can tell’. There are many stimuli that we pick up without being aware of picking them up. We learn without awareness of that is being learned. This type of knowledge has been described in different terms by various researchers.

Spender (1996) considers that a large part of our knowledge is “automatic knowledge”. We don’t know where it comes from, and we cannot tell that we know, though “it is here” and “it works”. We often rely on “practical knowledge” that we are not able to isolate, define or describe, for we acquire it through mindless and automatic practice. “Tacit knowledge” does not mean knowledge that cannot be codified, but is best defined as “knowledge not yet explicated”. This “procedural knowledge” (Anderson, 1976) is difficult to share, and when somebody replaces us at our tasks, the know-how is difficult to transfer.

The dynamics of knowledge involve continuous movements, exchanges and transformations of one type of knowledge into another (Nonaka, 1994). Tacit knowledge can be articulated in more explicit rules and then it becomes explicit knowledge. When we are faced with an explicit piece of knowledge, we then have to integrate it into behaviour and action. We achieve this task through practice in accordance with explicit rules, techniques, scientific findings, etc. we internalise these elements of explicit knowledge in our tacit knowledge and make them ours.

Stenmark (2002) concludes the knowledge viewpoints as two separate tracks: the commodity view and the community view. The commodity view of knowledge as

some absolute and universal truth has since long been the dominating view within science. Rooted in the positivism of the mid-19th century, the commodity view is still especially strong in the natural sciences. Disciples of this tradition understand knowledge as an artefact that can be handled in discrete units and that people may (or may not) possess. In this objectivistic approach, knowledge is a thing for which we can gain evidence, and knowledge as such is separated from the knower (Spender, 1998). Metaphors such as drilling, mining, and harvesting are used to describe how knowledge is being managed. There is also a shorter tradition that can be labelled the community view or the constructivist approach. This tradition is rooted in the critique of the established quantitative approach to science that emerged primarily amongst social scientists during the 1960's, these scientists think that reality (*and hence also knowledge*) should be understood as socially constructed. According to this tradition, it is impossible to define knowledge universally; it can only be defined in practice, in the activities of and interactions between individuals.

For the commodity viewpoint, this research considers that knowledge could be separated from “knower” and can be handled in discrete units, but this research considers that once knowledge is separated from “knower”, it is banked as information, and it will become knowledge only with comprehension of a new “knower”.

For the community viewpoint, the advocates take it as granted that reality is knowledge, which is different from this research viewpoint. This research views knowledge as solution rather than reality, though mastering reality and truth could make the solution process smoother, but the ultimate objective is about resolving problems. This will be detailed in the next section of working definition about data, information and knowledge. Another difference is the comprehension of knowledge. This viewpoint considers that knowledge doesn't exist when knowledge cannot be used and proved in proper context. But this research considers that knowledge still resides there in that context and its potential would be realized in certain



circumstances.

### **2.1.2.3 Working definitions for this research**

All of the discussions and definitions are based on one presumption that information is transferred to knowledge once relevant information is integrated into the existing knowledge body, and this transformation is regarded as a one-way transformation process. But this research considers that the process of transferring information into knowledge takes several steps and the transforming processes are two-way rather than one way. This is to say, knowledge could be transformed as information as well as information could be transformed into knowledge. The transforming process varies according to environment and background of every individual.

Therefore, the working definitions of data, information and knowledge transforming process are proposed as follows:

- **Data:** a set of record of events. Data could be structured or non-structured. For example, continuously monitoring and recording of temperature in grid paper is structured data, but a diary, several statements about a historic event could be unstructured data in analysing process. Data could be also objective and subjective, as most data are recorded by human being, --though sometimes via instruments— existing knowledge and concepts could affect the way of recording. In addition, data could also be quantitative and qualitative.
- **Information:** information is systematically interpreted data, which provides meaningful explanation of data for judgement.
- **Knowledge:** Knowledge should be recognition, understanding of a solution about a particular problem. The solution is the final aim for knowledge and learning, the capacity of solving a problem is the benchmark for knowledge. As Nonaka and Takeuchi (1995) point out, knowledge is always about action – the knowledge

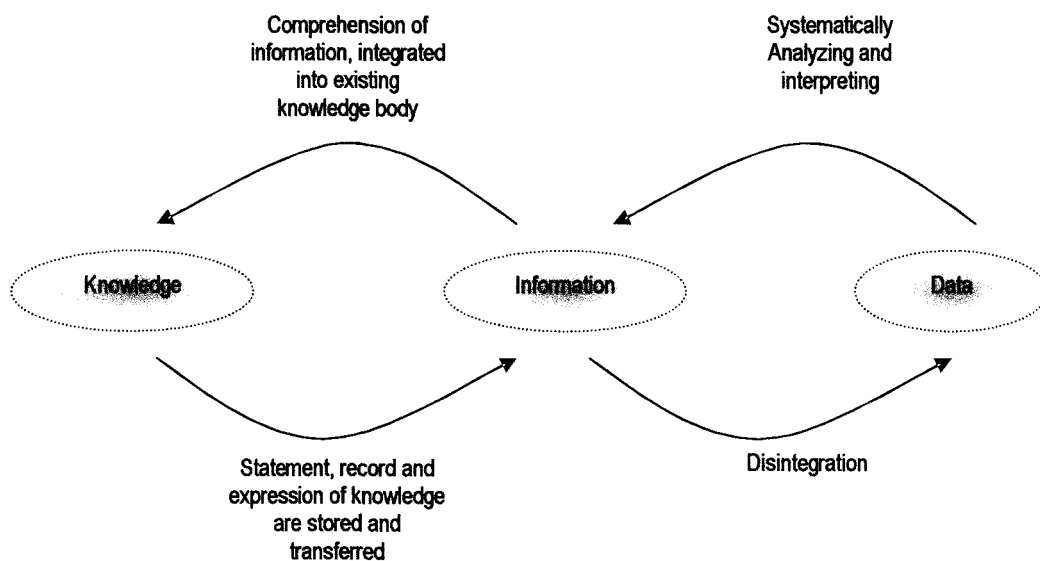
must be used to some end (pp. 57-58).

Also, Sveiby (1997, p. 37) defines knowledge as “a capacity to act”, this research goes a little further by defining an aim of the act.

In defining knowledge, some relevant concepts must be explained in detail. First of all, the target or the purpose of particular problem must be stated clearly. Otherwise, the boundary of knowledge body cannot be defined clearly. Secondly, knowledge is about solution of problem, not about the truth of the world. Although mastering truth of the world could assist in finding a solution for a problem. Considering the development of science, most ancient science is far away from the truth of the world. But they are still solved problems according to their knowledge at that age. On most occasions, people could solve problems without correct explanations for what is happening. It maybe considered that knowledge is about the ‘correct explanation’ about the world, but the ‘correctness’ is relative rather than absolute.

Hence, knowledge and information are similar in some aspects. However, knowledge and information are also different. While information is more factual, knowledge is about beliefs and commitment. Information has little value and will not become knowledge until it is processed by the human mind (Ash, 1998). Knowledge involves the processing, creation, or use of information in the mind of the individual (Kirchner, 1997). Knowledge is a high-value form of information that is ready to be applied to decisions and actions (Davenport *et al.*, 1998).

In contrast with other hierarchical structures of data, information and knowledge, this research adopts the following structure for the three terms:



*Figure 2.3 data, information and knowledge transferring process*

In this structure, a set of data is analysed and interpreted as meaningful information to support judgement and further actions. In extreme occasions, a single figure, one datum could be interpreted as information because some certain data are meaningful by themselves in certain circumstances. Information becomes knowledge only when the information is fully integrated into human brain and consequently the person could master the relevant information to reach certain aims, normally those aims are solutions for particular problems.

This diagram adopts a flat structure rather than hierarchical structure for two reasons: First of all, all authors using a hierarchical structure presume that data is converted into information and consequently information is converted into knowledge ( i.e., they consider the conversion process is one way) where the structure adopted here considers this as a two ways process.

As Stenmark (2001) points out, we have on several occasions used our knowledge to derive information and created data out of information.

Secondly, the hierarchical structure suggests that knowledge is more valuable than information, which in turn is superior to data (Stenmark, 2001). Tuomi (1999) argues that data emerges as a result of adding value to information, which in turn is knowledge that has been structured and verbalised. According to her view, there is no “raw” data, since every measurable or collectable piece of fact has already been affected by the very knowledge process that made it measurable and collectable in the first place. Tuomi (1999) consider that knowledge is embedded in our minds and is prerequisite. Human being can instantiate some of this knowledge as information, which is explicit and processable. By examining the structure of this information, we may finally codify it into pure data, which, from an IT perspective, is the most valuable of the three. Since only data can effectively be processed by computers, the value hierarchy should thus be turned around and have data on top (Tuomi 1999).

So many authors have discussed the difficulties in knowledge transferring process and introduced the term of tacit knowledge to explain the difficulties (see Nonaka, 1994; Boisot's ,1995; Choo, 1998; 2000; Blackler, 1995; Collins ,1993; Spender 1996). All of the debates are emanate from the phrase “tacit knowledge”, but the phrase explicit knowledge has been questioned by Stenmark (2001), who claims that all knowledge is tacit, and explicit “knowledge” is in fact information.

Therefore, this research doesn't adopt the concepts of explicit knowledge and tacit knowledge. It simplifies the concepts as data, information and knowledge. In the framework presented above, knowledge is transformed back into information before it is delivered to the recipients, which means, knowledge is transferred as meaningful information rather than knowledge itself when it is recorded, stored, and expressed by all means. The delivered information becomes knowledge only when the recipient has deep understanding of the information and could use the relevant information to solve some particular problems. Dougherty (1999) suggests that information could come from somewhere else, whereas knowledge comes as a person uses information and combines it with their personal experience. Information becomes knowledge when it

has been digested and thought over by a person's mind. There is always lots of data available but it is the individual that interprets data through information, chooses to make use of it and so create knowledge.

Various concepts could be explained based on this proposal. A library, a computer, the internet, they could all be full of useful information rather than knowledge, information becomes knowledge only when the subjective individual has a deep understanding and mastered relevant information. A lecturer sends information to students and the information become students' knowledge only when the information is integrated into students' knowledge body. Before students have comprehension of what the lecturer taught, the information is just information rather than knowledge. Students keep information in their brain like a library keeps books or a computer keeps files. To test if the sent information has become knowledge residing in students, the lecturer could check the comprehension and integration by examination. Therefore, information is stored in the human brain and transferred into knowledge only when the individual has comprehension of the information and could use the relevant information to solve problems. Solving problems is a test for comprehension; consequently the test could prove if information resides as knowledge in every individual.

Based on these definitions and explanations, the difficulties in the learning and knowledge transferring processes can be explained in the following way

First of all, difficulties exist in the information recording and storing process. Information is conveyed by a variety of means, such as language, facial expression, behaviour and attitude. Although linguistic methods are the main means of recording information, its transfer is not limited to this medium. Indeed, 'tacit knowledge' is built on the recognition that some knowledge is difficult to express by language. Almost all linguistic media are relatively easy to be used and stored, but other means of vehicles for information are necessary for transmitting correct information in most

circumstances. As the first step of transferring knowledge is sending correct information to the receiver, knowledge should be transferred as information by a similar variety of means rather than just paperwork, because information is difficult to be expressed and transferred as information only by language. Although music could be recorded as music scores, the transformation process would lead to loss of rich information. Music should be transferred as music itself. But most occasions, this transferring vehicle is limited to language which leads to difficulties in comprehension.

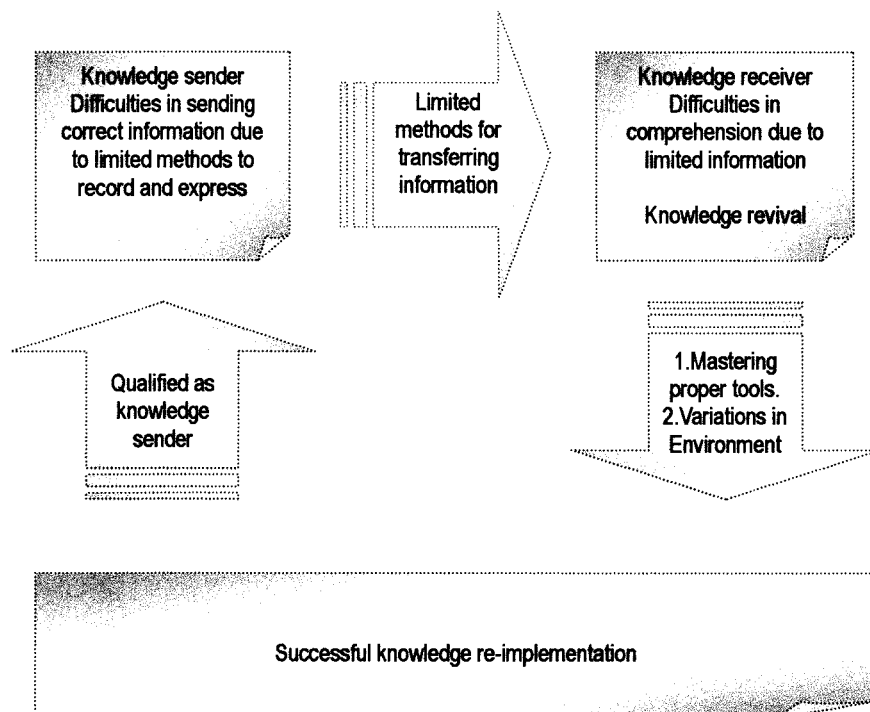
Secondly, people have difficulties in understanding and integration of all relevant information in solving problem due to bounded rationality, especially in the diversified technology development era. The concept of bounded rationality comes from the school of thought about decision-making that is developed from dissatisfaction with the 'comprehensively rational' economic and decision-theory models of choice. Bounded rationality asserts that decision-makers are intendedly rational; that is, they are goal-oriented and adaptive, but because of human cognitive and emotional architecture, they sometimes fail, occasionally in important decisions. Limits on rational adaptation are of two types: procedural limits, which are limits on how we go about making decisions, and substantive limits, which affect particular choices directly (Jones, 1999).

In the implementation process, difficulties come from two aspects. One is from the subject who implements knowledge for problem solving. In applying knowledge for problem solving, it involves skills of mastering some tools in most occasions, especially in modern society, such as computer for office staff, gun for soldiers, hands for handmade craft. The skill of applying tools will affect the result and quality of outcomes.

Another difficulty in knowledge implementation process comes from the environment. Two elements in environment have to be taken into account: *constant* and *variables*.

In implementing knowledge in practice, some elements in the process are constant because they don't change along with different occasions and environments, but the other elements change along with the different process, occasions and environments. These changes in variables lead to some difficulties in the knowledge implementation process, consequently the variable leads to differences in theory and in practice. In the knowledge transferring process, most constant elements are considered as basic context, but it is not possible to list all the variables. In some circumstances, constants could become variables due to different culture, background and comprehension. In other circumstances, variables could become constants due to shared culture, background and comprehension.

These difficulties can be explained in the following diagram



*Figure 2.4 knowledge transferring process and its difficulties*

In summary, this section has presented some basic concepts including data,

information and knowledge. In order to develop this research on a clear and sound basis, this section firstly reviewed relevant schools of thought about definitions regarding data, information and knowledge. It then presented original working definitions and explanations about difficulties in knowledge transferring and management process. Based on these basic concepts and distinctions, the next section will review the relevant Knowledge Management concepts and perspectives in business practice.

## **2.2 Knowledge Management, concepts and perspectives**

Based on the clarification of the basic concepts about data, information and knowledge, this section goes further to explore how knowledge is managed as an important resource in practice. However, knowledge has always been a valuable asset (Chase, 1998).

Along with technological development, new viewpoints about management in practice emerge from different considerations over past decades, such as competitive advantage, total quality management (TQM), Supply Chain Management (SCM) and business process re-engineering (BPR) concepts. Resource based competitive advantage is nothing new, but only in recent years has knowledge been regarded as the most important resource over other resources such as capital in organizational management. Scholars and observers from disciplines as disparate as sociology, economics, and management science agree that a transformation has occurred, and that “knowledge” is at centre stage (Davenport *et al*, 1998).

Not surprisingly, Knowledge Management and related strategy concepts are promoted as important and necessary components for organisations to survive and maintain



their competitive keenness. It has become necessary for managers and executives to address Knowledge Management (Goodman and Chinowsky, 1997).

Despite the arguments about whether knowledge can be managed, some schools of thought on Knowledge Management are widely accepted in this field.

Alavi & Leidner (2001) provide three distinctive perspectives on Knowledge Management. These Knowledge Management perspectives are information-based, technology-based and culture-based. Information-based perspective is about the characteristic of information in the systems, while technology-based perspective emphasizes how diverse information technology systems and tools support Knowledge Management implementation. A culture-based perspective relates Knowledge Management with learning, communication and intellectual property cultivation.

Also, Alinda and Hasliza (2004) conclude that all Knowledge Management could be classified from three perspectives

Classification of criteria	Technical	Organizational	Personal
	Computer science and information technology communities perspective on Knowledge Management: the technology, system design, system implementation.	Management and business communities perspective on Knowledge Management: enhance performance, increase collaboration, improve customer service, classified knowledge	Psychology and sociology communities perspective on Knowledge Management: attitude and behavior

*Table 2.3 Three perspectives on Knowledge Management research*

(Adopted from Alinda and Hasliza, 2004)

This research follows the organizational perspective. It is concerned with Knowledge Management that increases the collaboration between construction teams, enhances overall project performance and improves customer service.

The organizational perspective on Knowledge Management research is discussed

mainly by social science and business and management communities. Knowledge Management success depends upon the combination of technology, organizational culture and organizational context issues (Alinda and Hasliza, 2004). Given that all organizations seek to use possible resources to maximize value creation; they have started to recognize knowledge as one of the important elements of competitive advantage that needs to be utilized efficiently and effectively (Ginsburg & Kambil, 1999).

Barnes (2002) explains that business strategy is influenced by two elements within the resource-based view of the organization. The first element is organizational resource consisting of equipment, skills, patents and financial capital. Another element is organizational capabilities, which are utilizing the organizational resource according to organizational operations and business processes. The emergence of knowledge makes it a new element in resource-based perspective and the function of organizational capabilities is to manage the knowledge strategically (Barnes, 2002).

Based on this, Barnes (2002) identifies three dimensions of focus for capabilities of organizations in managing their knowledge:

- Enhance performance – reduced problem-solving time, faster result, and faster delivery-cycle time.
- Increase collaboration – improved communication, increased staff participation.
- Improve customer service- better service, more customer focus

In order to explore and exploit the potential value of knowledge as an organizational asset, it is important to identify and classify the organizational knowledge according to its function. Organizational knowledge is embedded in human resource, business activities and processes, and organizational artefacts (Alinda and Hasliza, 2004).

## 2.2.1 Concept of Knowledge Management

A widely used working definition of Knowledge Management is: The collection of processes that govern the creation, dissemination and leveraging of knowledge to fulfil organisational objectives (Davenport and Prusak, 1998). Knowledge Management is concerned with the exploitation and development of the knowledge assets of an organisation with a view to furthering the organisation's objectives. The knowledge to be managed includes both explicit, documented knowledge, and tacit, subjective knowledge. Management entails all of those processes associated with the identification, sharing and creation of knowledge. This requires systems for the creation and maintenance of knowledge repositories, and to cultivate and facilitate the sharing of knowledge and organisational learning. Organisations that succeed in Knowledge Management are likely to view knowledge as an asset and to develop organisational norms and values, which support the creation, and sharing of knowledge (Davenport and Prusak., 1998)

Based on these definitions, it is recognised that Knowledge Management is seen as relating to both theory and practice. Knowledge Management is not situated purely in the domain of technology. Although recent advances in technology have led to faster data transfer, it remains a useful enabler rather than a central tenet at the heart of *Knowledge Management*. The central issues to Knowledge Management are *people* and their *learning*. Knowledge Management is the activity which is concerned with the strategy and tactics to manage human centred assets (Brooking, 1997). From this standpoint, Knowledge Management is seen as leveraging intellectual capital (IC) (Peters, 1992), or as recognising or rediscovering assets (ultimately employees) that the organisation is not using to full potential.

When discussing Knowledge Management in business practice, knowledge is always viewed as intellectual capital. In fact, the field of Knowledge Management can be

seen as an integral part of the broader concept "intellectual capital" (Roos *et al.*, 1997). Guthrie (2000) makes the following distinction between Knowledge Management and "intellectual capital". Knowledge Management is about the management of the "intellectual capital" controlled by the company. However, too often the delineation between the two terms is unclear and seldom adequately addressed (Guthrie, 2000).

Levett and Guenov (2000) consider that Knowledge Management is the examination of mechanisms that facilitate critical organisational processes, the measurement of their performance and the development of practical solutions that deliver one or more Knowledge Management objectives. However, this viewpoint doesn't distinguish Knowledge Management from other management methods, such as ERP(Enterprise Resource Planning) and information management.

Martensson (2000) concludes that Knowledge Management consists of separate but related stages.



*Figure 2.5 The stages of Knowledge Management*

(Adopted from Martensson, 2000)

According to Martensson (2000), the first two stages are invariably linked, both on abstract theoretical grounds and in practice. As the first step in the process, there is acquisition of information. In the second stage, the information is entered into a storage system and organised logically. Knowledge Management is about acquisition and storage of workers' knowledge and making information accessible to other employees within the organisation. Martensson (2000) explains this process as how people store information, how to clarify information to make information easily

accessible to the right people at the right time, but he did not distinguish the differences between information management and Knowledge Management, and in fact this model could be considered as information management in practice.

Martensson (2000) also suggests that the management of knowledge could be examined from two theoretical perspectives. The first one involves theories where the focus is on the individual's knowledge; the second perspective comprises theories wherein the knowledge itself is the centre of interest. Human capital is defined by Flamholtz (1985) as "the knowledge, skills and experience of people". Within human capital theories, the employee is regarded as the bearer of knowledge. Another perspective, in which knowledge is the centre of interest, is the knowledge-based theory of the firm. In such theories, the individual exists but the focus is more on knowledge than the individual. The two perspectives could be described as being either individualistic or holistic. From a holistic view, the sum of an organisation is more than the sum of the individuals, whereas from an individualistic view, the sum of an organisation is the sum of the individuals (Hollis, 1994). Within the recent theoretical development (i.e. knowledge-based theories of the firm), the focus has shifted from an individual perspective to an emphasis on knowledge residing in the organisation as a whole, i.e. a holistic approach (Martensson, 2000).

### **2.2.2 Managerial concerns in practice**

Authors have suggested various approaches for managing knowledge in practice. Though they have shared aims for managing knowledge, the approaches have fewer similarities.

For sustaining Knowledge Management processes, both "hard" conditions and "soft" environments have to be created and nurtured. The hard side refers to technological

platforms (including facilities and necessary devices). The soft side consists of trust, team spirit and learning climate for improving contributors' productivity. At the organizational level, distinctive organizational visions and strategies are formulated to guide and regulate Knowledge Management; relevant evaluation and reward institutions are to be created to define responsibility and liability of individual and organization (Gao *et al*, 2002).

For the successful implementation of Knowledge Management, some authors emphasize the importance of Knowledge Management as a new management method and suggest critical issues.

Despres *et al* (1999) consider that companies that implement Knowledge Management do so in a variety of ways, ranging along certain dimensions:

- Knowledge as a variable of the firm, versus knowledge as the firm itself.
- Fundamental and strategic commitment, versus fad following.
- As a change vehicle, versus strengthening existing arrangements.
- Through and primarily based on technologies (typically electronic), versus people.
- Knowledge as a source of innovation, value creation.
- A new approach to human resource management: individual responsibility for knowledge sharing and learning.

The reasons that business organizations adopt systematic Knowledge Management are:

- To make the enterprise act as intelligently as possible to secure its viability and overall success.
- To otherwise realize the best value of its knowledge assets. (Wiig, 1993)

In order to reach these goals, advanced organizations build, transform, organize, deploy and use knowledge assets effectively. Stated differently, the overall purpose of

Knowledge Management is to maximize the enterprise's knowledge-related effectiveness and returns from its knowledge assets and to renew them constantly. Knowledge Management is to understand, focus on, and manage systematic, explicit, and deliberate knowledge building, renewal, and application – that is, manage Effective Knowledge Processes (EKP) (Wiig 1997).

From a managerial perspective, Wiig (1997) proposes four areas of emphasis in systematic Knowledge Management:

- Top-down monitoring and facilitation of knowledge-related activities.
- Creation and maintenance of the knowledge infrastructure.
- Renewing, organizing, and transforming knowledge assets.
- Leveraging (using) knowledge assets to realize their value.

These are presented in figure 2.6

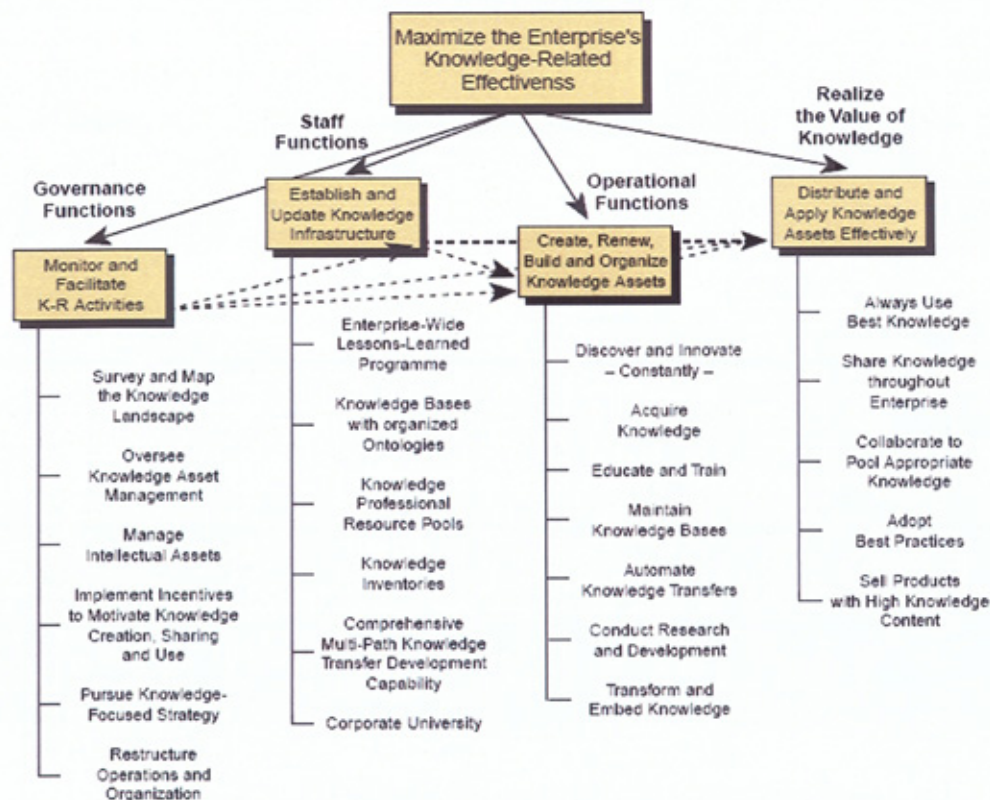


Figure 2.6 Four areas of Knowledge Management emphasis

(Adopted from Wiig, 1997)

For an initial Knowledge Management introduction programme, Wiig (1993) offers a six-step procedure for an organisation with limited experience in Knowledge Management:

- Build management understanding and commitment to pursue Knowledge Management.
- Map perspectives of the knowledge landscape.
- Plan the organisation Knowledge Management priorities, focus and strategy.
- Identify Knowledge Management benefits.
- Adjust Knowledge Management priorities.
- Create KM-related incentive programmes.

But in practice, Levett and Guenov (2000) argue that this procedure is too broad and generic and it is hard to be implemented. Without a certain context, this procedure could just be a starting point for considering Knowledge Management.

Also, Wigg (1997) advocates five basic knowledge-centred strategies in business organizations:

- Knowledge strategy as business strategy – a focus on knowledge creation, capture, organization, renewal, sharing and use to have the best possible knowledge available – and used – at each point of action.
- Intellectual asset management strategy – a focus on knowledge enterprise-level management of specific intellectual assets such as patents, technologies, operational and management practices, customer relations, organizational arrangements and other structural knowledge assets.
- Personal knowledge asset responsibility strategy – a focus on personal knowledge responsibility for knowledge-related investments, innovations and the competitive state, renewal, effective use, and availability to others of the knowledge assets within each employee's area of accountability to being able to apply the most competitive knowledge to the enterprise's work.
- Knowledge creation strategy – a focus on knowledge learning, basic and applied



research and development, and motivation of employees to innovate and capture lessons learned to obtain new and better knowledge that will lead to improved competitiveness.

- Knowledge transfer strategy – a focus on knowledge systematic approaches to transfer – obtain, organize, restructure, warehouse or memorize, repackage for deployment and distribute – knowledge to points of action where it will be used to perform work. Includes knowledge sharing and adopting best practices.

But in implementation process, it is hard to distinguish the five strategies from each other; in fact, every strategy would involve activities in other four strategies.

When reviewing Knowledge Management initiatives implementation, Davenport and Prusak (1998) highlight the difference between the more formalised transfer mechanisms such as documents, databases, intranets and groupware, and informal exchanges which are more casual events that usually take place face to face i.e. in conversation. These unstructured exchanges “are vital to a firms success” and one of the essential elements of Knowledge Management is to “develop special strategies to encourage such spontaneous exchanges” (p. 89).

Von Krogh *et al.* (1996), take a more social perspective and describe “knowledge connections”, which provide the potential for people to convey messages. These are principally made up of relationships, both those formed on an informal basis and those that occur through more formal means as a result of structure and the underlying culture of an organisation. At this level, potential connections, such as when a customer asks for types of services other than those obviously provided by the organisation, may be ignored or filtered out.

Alternatively, Dougherty (1999) points out that Knowledge Management as a discipline must avoid this danger and must be allowed to evolve through dialogue and debate.

In business operation, Knowledge Management can provide the corporate world with a framework around which organisational leaders can structure debate at a strategic level. Such dialogue could not only bring to the fore a recognition of the importance of people but it also may lead to decision makers in organisations acting in a manner that models knowledge transfer and connection. They will therefore be ``doing" people-centred Knowledge Management as knowledge connection takes place (Dougherty 1999).

## 2.3 Knowledge Management, theoretical models

Authors have presented distinctive Knowledge Management models from a variety of perspectives. These models integrate key elements in Knowledge Management and formulate their relationships. In order to form a base for further investigation, existing Knowledge Management models are reviewed in detail and compared in this section.

Hedlund and Nonaka introduce the Knowledge Management model shown in Figure 2.7 (Hedlund and Nonaka ,1993).

	Individual	Group	Organisation	Interorganisational domain
Articulated knowledge	Knowing calculus	Quality circle's documented analysis of its performance	Organisation chart	Supplier's patents and documented practices
Tacit knowledge	Cross-cultural negotiation skills	Team coordination in complex work	Corporate culture	Customer's attitudes to products and expectations

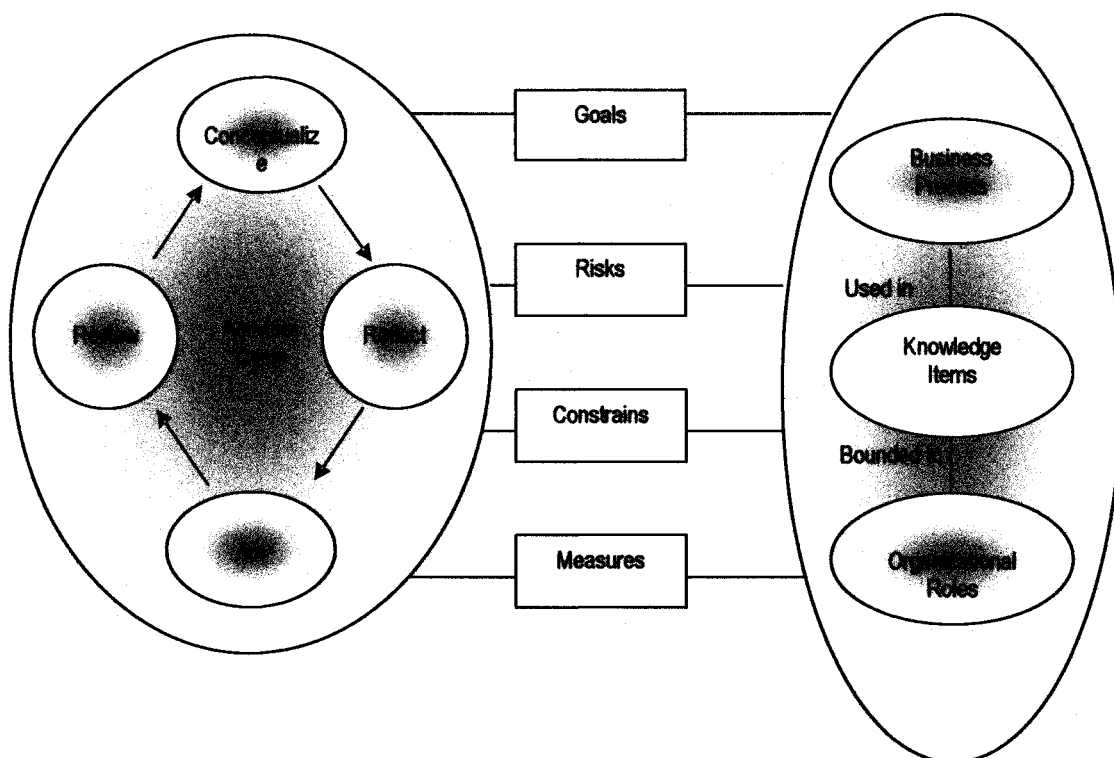
*Figure 2.7 Knowledge Management model*

(Adopted from Hedlund and Nonaka ,1993)

This model identifies four categories in which knowledge reside, individual; group; organization and inter-organization domain. This model also pointed out different tacit

knowledge to support Knowledge Management. But the problems are obvious. First of all, the four categories, individual, group, organization and inter-organizational domain, are tightly related to each other and it is almost impossible to separate them from each other in applying this model to practice. Also the articulated knowledge and tacit knowledge are indeed interwoven, it is impossible to point out which is explicit knowledge and which one is tacit. Knowledge is dynamic rather than static; the tacit dimension could be transferred into the explicit one with the development of modern technology. All knowledge should be measured in a spectrum with explicit and tacit on each poles, and all knowledge has certain degree of the tacit dimension and explicit dimension, rather than being split into tacit and explicit categories.

Wiig (1993) develops another Knowledge Management model to link certain Knowledge Management activities and relevant objectives.



*Figure 2.8 Knowledge Management framework*

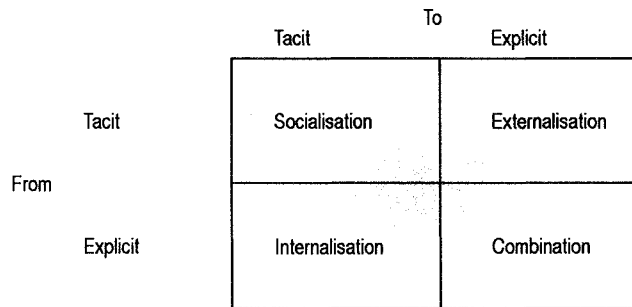
(Adopted from Wiig, 1993)

The activities cycle in the left hand side of Figure 2.8 represents the Knowledge Management level. *Conceptualize* is getting an insight into what knowledge "is" (surveying, classifying, modelling). *Reflection* is appraising knowledge against a set of criteria (assessment, evaluation, bottlenecks). *To act* is to operate on knowledge objects to improve business process and performance (acquires, distribute, facilitate). *Review* is to assess the effect of the actions in terms of what was meant to be achieved (appraise, evaluate). And then the cycle continues again.

On the right hand side of the figure is the knowledge object level whereby business processes are used in knowledge items which are bound to organizational roles. The goals, risks, constraints, and measures are the support areas setting "goals" for a Knowledge Management cycle; establishing and evaluating "risks" that can occur in a cycle; modelling formalisms and tools for supporting conceptualizing and "constraints" affecting knowledge; Applying "measures" for supporting actions that can be undertaken and techniques for appraising knowledge (Wiig, 1993)

Compared to Hedlund and Nonaka's model, this Knowledge Management model takes more issues into account and provides detailed steps and elements in Knowledge Management. But in practice, knowledge creation process cannot be analysed according to this structured process. Allee (1997a) points out that knowledge indeed is "messy" and impossible to impose rules and systems. Knowledge is self-organizing, the most important way to advance it is to remove the barriers to self-organization. In a supportive environment, knowledge will take care of itself.

Later Nonaka and Takeuchi (1995) developed another simpler model regarding knowledge creation and sharing( shown in Figure 2.9). This widely cited model proposes the transformation process between tacit knowledge and explicit knowledge,



*Figure 2.9 Simpler Knowledge Management model*

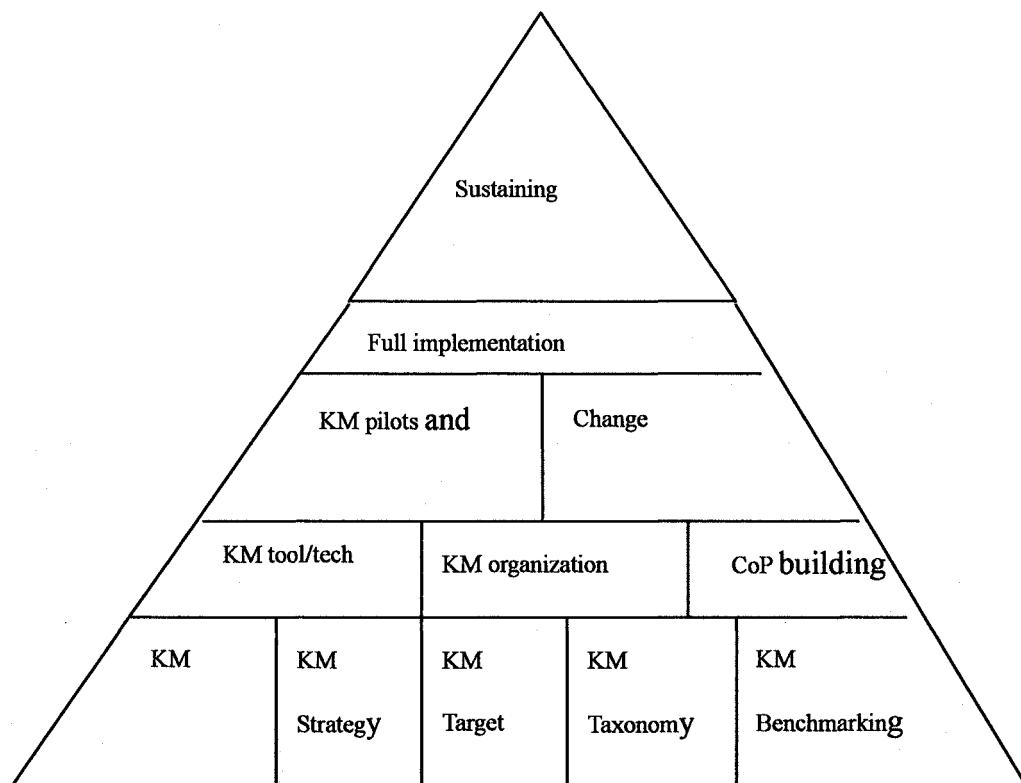
(Adopted from Nonaka and Takeuchi, 1995)

This model also acknowledges that all knowledge has tacit and explicit dimensions, and these two dimensions can be transformed by certain activities. Tacit knowledge can be transformed to explicit one by externalisation; explicit knowledge can be transformed into tacit one by internalization. Socialization can help tacit knowledge exchange and combination can enable explicit knowledge sharing. This model has noticed the social dimension of knowledge sharing and transferring, but lacks detailed explanation about how to realise “socialization”, “externalisation”, “internalisation”, and “combination”.

From an organizational management viewpoint, Gold *et al.* (2001) state that organizational structure is an important factor in leveraging technology and more specifically that organizational structures must be flexible to encourage sharing of knowledge and collaboration across traditional organizational boundaries to promote knowledge creation. Similar to Wigg’s (1993) model, this viewpoint draws attention to formalizing Knowledge Management in a structured process, the social dimension should be taken into account, sometimes people just don’t share there knowledge even when the formal channels and structures are facilitating the process.

Liebowitz and Megbolugbe (2003) suggest that building a knowledge-centric organization has several key elements as critical success factors, as shown in figure 2.10, the basic building blocks are creating an awareness of Knowledge Management, performing Knowledge Management benchmarking to see what other similar organizations have done, developing a knowledge taxonomy which serves as a

vocabulary and structure in which to construct the Knowledge Management system, developing a Knowledge Management strategy, and pinpointing target areas for greatest use of Knowledge Management activities. Then, the next level involves selecting appropriate Knowledge Management technologies and tools, developing a Knowledge Management organizational infrastructure, and building and nurturing online communities of practice (CoP). Subsequently, Knowledge Management pilots can be conducted and measurements made, along with instituting a change management process within the organization. Finally, full implementation of the Knowledge Management systems, processes, and practices can be made, with the constant sustaining and extending a knowledge sharing culture.

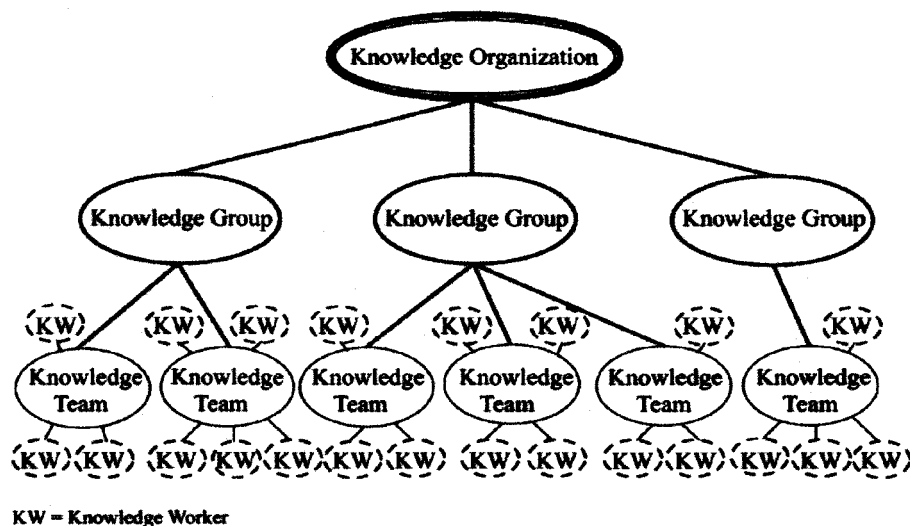


*Figure 2.10, Knowledge Management pyramid and a knowledge-centric organization*

(Adopted from Liebowitz, and Megbolugbe, 2003)

The pyramid thinking of knowledge-centric organization is unique but also a little problematic. For example, Knowledge Management benchmarking is desirable but hard to achieve. Knowledge Management facilitates overall business performance but the quality of Knowledge Management cannot be measured, sometimes it may cause information overload. People cannot tell where and when they will benefit from Knowledge Management events and activities, due to the dynamic and different backgrounds of the knowledge body.

Also from an organizational viewpoint, Walczak (2005) proposes that a knowledge organization could be viewed as the following structure in order to manage their knowledge activities well



*Figure 2.11 Knowledge Management structure*

(Adopted from Walczak ,2005)

Walczak (2005) concludes (see figure 2.11) that organizations that attempt to introduce a Knowledge Management initiative without having a managerial support structure will soon find that the investment in Knowledge Management does not produce any perceived benefits. This model attempts to provide a Knowledge Management structure for effective Knowledge Management but this model is too general to be applied in practice. More specific detailed planning environmental

analysis are necessary for implementation.

In this Knowledge Management structure, Walczak (2005) suggests that individual personnel in knowledge organization should be viewed as knowledge workers. This recognition will promote the development of new knowledge teams to address an organization's opportunities and consequently will facilitate the development of knowledge team communities that are diverse and more focused on knowledge-oriented problem solving. In this management model, knowledge workers are expected to share and utilize knowledge with other team members to produce the highest quality decisions. New knowledge teams and groups must be promoted to develop around product lines or other core competencies of the enterprise as opposed to functional area team composition. Knowledge teams should be created dynamically to take advantage of an organization's business opportunities or new business strategies (Walczak 2005).

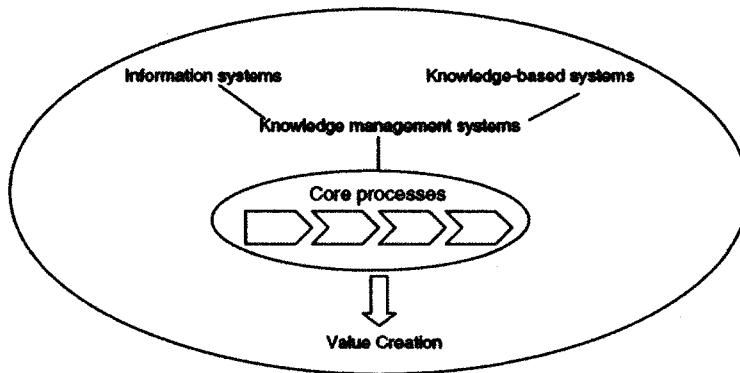
Benbya and Belbaly (2005) go further by developing a more feasible theoretical model. They propose that the development of Knowledge Management system should fit the overall organizational culture and structure. Benbya and Belbaly (2005) advocate the implementation of Knowledge Management system (KMS), which is a new line of IT-based systems to support organizational Knowledge Management. KMS have been defined as a line of systems which target professional and managerial activities by focusing on creating, gathering, organizing and disseminating an organization's 'knowledge' as opposed to 'information' or 'data' (Becerra- Fernandez, 2000).

Benbya and Belbaly (2005) believe that Knowledge Management activities should be integrated within day-to-day business processes to ensure continual process improvement and facilitate learning and the gradual development of organizational memory. Companies should focus on specific business processes to implement Knowledge Management (Mertins *et al.*, 2001). In particular, organizations try to



sustain their core processes which represent the core competence and most important capability of the firm (Benbya and Belbaly, 2005).

Based on these thoughts, Benbya and Belbaly (2005) propose the following Knowledge Management systems foundations model,



*Figure 2.12 Knowledge Management systems foundations*

(Adopted from Benbya and Belbaly, 2005)

In this model, information systems and knowledge-based systems support a Knowledge Management system which follows business core processes and the final aim is value creation for business.

Based on the definitions of knowledge and discussion of Knowledge Management, this section reviews existing models of Knowledge Management. From different viewpoints, a variety of authors suggest different approaches for managing knowledge. Basically all these approaches focus on two clusters: people (soft side) and information technology (hard side), and the interactions between them. For managing knowledge, first of all, an organizations needs information technologies to support managing activities, secondly, Knowledge Management needs proactive personnel in knowledge sharing and diffusion. Therefore, relevant Knowledge Management environments (such as a learning culture) should be created for Knowledge

Management activities.

## **2.4 Knowledge Management in the construction industry**

From the above review, it can be concluded that Knowledge Management is vital for business organizations, “the successful economies of the future will be those which excel at generating and disseminating knowledge and exploiting it commercially” (UK White Paper 2000). Organizational knowledge has become the most valuable resource in knowledge economy than other traditional resources such as capital and material (Drucker, 1993; Scarbrough *et al*, 1999).

Following Latham (1994) and Egan (1998)’s report, the construction industry in the UK has been in transition to overcome its perceived performance problems.

Knowledge and learning have been regarded as core competences for the construction industry in order to improve overall performance (see CRISP, 1995; OST, 1995).

Knowledge Management is regarded as vital for efficiency in project delivery and improving organizational competitiveness (Egbu, 2001). Initially when adopting Knowledge Management, the major challenge for construction organisations is to transfer knowledge and information across projects, because much construction work is project-based, short-term and task-oriented, promoting a culture where continuous learning is inhibited. Specialist and technical knowledge is lost from one project to the next restricting the ability to develop knowledge and generate new ideas (Egbu & Botterill, 2002). With the increasing pressure for competitiveness on construction organisations, it is necessary to capture, transfer and reuse project knowledge and use lessons learned from previous projects to improve project performance (Lee and Egbu, 2005). By reviewing relevant literature, Chan *et al*. (2006) confirm that the concept of knowledge remains abstract and Knowledge Management requires better exploitation

in construction industry. For example, they consider that the links between knowledge and organizational productivity, and the use of knowledge by human resources, remain relatively unexplored. Chan *et al.* (2006) term the situation of not fully exploiting existing knowledge as the concept of “knowledge leakage”. However, there are still needs for empirical research studies in project-based environments and in the Built Environment disciplines (Egbu, 2001).

Despite the difficulties and debate, some schools of thought have developed certain theoretical frameworks which attempted to tackle Knowledge Management challenges in construction industry; the following section is to review the existing frameworks to set background for Knowledge Management in construction industry in the UK.

### **2.4.1 Challenges and solutions---existing models**

When Knowledge Management has been gaining increasing attention in business management, the term ‘Knowledge Management’ is relatively new to construction organisations and there continues to be a debate on how it could be achieved in construction project context (Carrillo *et al.*, 2000).

Egbu (2001) considers that Knowledge Management from a project perspective is about harnessing individual and project knowledge to the benefit of the project. He regards the challenges are from two perspectives. The first is to recognise the particular constraints imposed on Knowledge Management processes by project environments. And the second is to find the means of creating, transferring, sharing, implementing and exploiting individual and project knowledge in such a way that they lead to project success and provide benefits to project clients.

Carrillo *et al* (2000) summarize the difficulties of Knowledge Management in

construction industry as ignorance of employees' value, the tacit dimension of project knowledge, hierarchical organizational structures and multi-disciplinary teams in project process.

To explain these in detail, Carrillo *et al* (2000) present the barriers in adoption of Knowledge Management in construction industry as:

### *1 Lack of Time*

Sharing knowledge demands additional effort. This effort may be minimised by work practices and the introduction of better knowledge sharing tools. Construction projects are always working to tight deadlines. Anything that detracts from the main business is seen as of diminished importance.

### *2 Trying to solve large problems*

The various stages involved in KM are complex. It is easy to envisage the utopian world of delivering knowledge to different members of the project team, as and when required, for different stages of the construction process. However, in reality, for a company embarking on Knowledge Management, it is best to undertake very small projects that are self-contained with little input from external parties.

### *3 Converting Knowledge*

One major obstacle is how organisations capture knowledge on projects that cut across organisational boundaries. The industry is full of individuals, skilled trade workers and professionals who have years of experience of doing specific tasks. Converting their tacit knowledge to explicit knowledge for the benefit of others is a problem, which is difficult to conduct within a reasonable period and at an acceptable cost.

### *4 Large number of SMEs*

The UK construction industry consists of a large proportion of small to medium-sized enterprise (SMEs). These organisations have more pressing concerns than KM and in many cases do not see the need nor do they have the commitment and resources to undertake KM.

### *5 Multi-Disciplinary Teams*

Some project team members may belong to different divisions or even different companies. Managing knowledge with such a team within a limited time period is difficult. Each team member will be working towards the agenda set by their employer. The benefits of KM may be seen as limited to the life of the individual project unless in long-term partnering type relationships.

### *6 Unique Projects*

Despite efforts to encourage the UK construction industry to view itself as a manufacturing enterprise, it still regards each project as a one-off. This reinforces the view that KM on individual projects will be wasted as the next project may be quite different.

### *7 Lack of Learning*

Because of the view of the industry producing unique projects, there has also been a failure to learn from past mistakes. In many circles, the UK construction industry is regarded as a national (rather than international) industry and there is an unwillingness to learn from internal and external sources.

### *8 Lengthy Time Period*

KM is a long-term goal without any short cuts. If it is to bring long-term benefit to the organisation, it will take a considerable period to have systems up and running with sufficient time to be validated and for benefits to percolate to the organisation's performance.

### *9 Loss of faith*

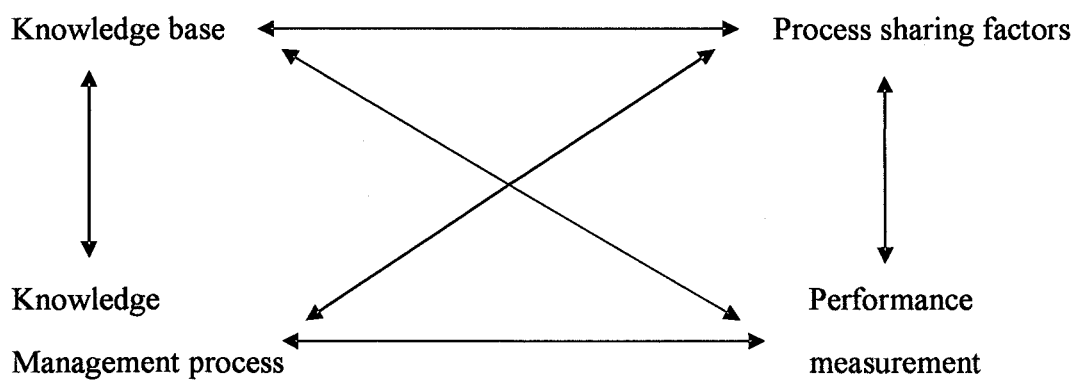
With KM systems available, employees may be tempted into thinking the data required is always easily accessible. In fact, it will take considerable time to get a spread of working KM systems. This may lead to employees losing faith in the system because it does not deliver immediate benefits in their own individual areas.

### *10 IT support*

Many of the existing systems rely on IT for delivery. Construction offices may be portacabins in isolated environments with inadequate infrastructure. The IT support, a key element in KM systems, must be present to deliver the knowledge required.

Based on current working practices and the barriers to KM, a discussion of the IT support required within the construction sector now follows (Carrillo *et al* 2000, p.161).

Furthermore, Carrillo *et al* (2000) develop a theoretical framework based on their identification of key issues



*Figure 2.13 Conceptual framework for Knowledge Management*

(Adopted from Carrillo *et al*,2000)

According to the authors, the knowledge base includes data, information, and knowledge. The Knowledge Management processes refer the actual processes, procedures and tools required to capture, share and reuse knowledge. Process shaping factors are issues that initiate the need for knowledge, and how it is applied within the organisational structure and culture. Finally, performance measurement is an indication or measurement of how managed knowledge is contributing to improved business performance, since Knowledge Management is not an end in itself, but a means to increased competitive advantage (Carrillo *et al* 2000).

In general, Carrillo *et al* (2000) are right in identifying barriers for Knowledge

Management implications in the construction industry, though some issues do overlap. This framework is also useful in applying Knowledge Management in construction industry, but the three categories, knowledge base, Knowledge Management process and factors shaping process should not be considered separately in implementation process, it is impossible to separate them from each other. All the three elements consist of Knowledge Management creation and implication process. Nevertheless, Carrillo *et al* (2000) notice the interactive relationships between the four elements; they fail to point out how the four elements interact in the organizational dynamic context, which is a key issue for Knowledge Management implication in construction industry. In the meantime, this framework cannot explain how to overcome the barriers they identified from the construction project context.

Wetherill *et al* (2002) classify knowledge in the construction domain into the three following categories:

- Domain knowledge: this forms the overall information context. It includes administrative information, standards, technical rules, product databases, etc. in principle this information is available to all companies, and is partly stored in electronic databases.
- Organisational knowledge: this is company specific and considered as intellectual capital. It resides both formally in company records and informally through the skilled processes of the firm. It also comprises knowledge about the personal skills, project experience of the employees and cross-organisational knowledge. The latter covers knowledge involved in business relationships with other partners, including clients, architects, engineering companies, and contractors.
- Project knowledge: this is the potential for usable knowledge and is at the source of much of the knowledge identified above. It is both knowledge each company has about the project and the knowledge that is created by the interaction between firms. It is not held in a form that promotes re-use (e.g. solutions to technical problems, or in avoiding repeated mistakes), thus companies and partnerships are generally unable to capitalise on this potential for creating knowledge. It includes

both project records and the, recorded and unrecorded, memory of processes, problems and solutions.

Wetherill *et al* (2002) identify the limitations in managing these three kinds of knowledge in construction industry as:

- Much construction knowledge, by necessity, resides in the minds of the individuals working within the domain.
- The intent behind decisions is often not recorded or documented. It requires complex processes to track and record the thousands of ad-hoc messages, phone calls, memos, and conversations that comprise much project-related information.
- People responsible for collecting and archiving project data may not necessarily understand the specific needs of actors who will use it, such as the actors involved in the maintenance of the building(s).
- The data is usually not managed while it is created but instead it is captured and archived at the end of the construction stage. People who have knowledge about the project are likely to have left for another project by this time - their input is not captured.
- Lessons learned are not organised well, and buried in details. It is difficult to compile and disseminate useful knowledge to other projects.
- Many companies maintain historical reports of their projects. Since people move from one company to another, it is difficult to reach the original report authors who understand the hidden meaning of historical project data. This historical data should include a rich representation of data context, so that it can be used with minimum (or no) consultation.
- New approaches to the management of knowledge within and between firms imply major changes in individual roles and organisational processes. While the potential gains are desired, the necessary changes are resisted.

After identification of the categories of knowledge and challenges in managing these knowledge and comprehensive analysis of the business and information / Knowledge



Management practices of the construction projects, Wetherill *et al* (2002) developed e- Cognos web-based infrastructure to the enhancement, development and improvement of professional expertise in the construction domain. With adoption of the latest development in Information and Communication Technologies, the e-Cognos infrastructure allows the creation, capture, indexing, retrieval and dissemination of knowledge. It aims to promote the integration of third-party services, including proprietary tools that promote consistent Knowledge Management within collaborative construction environments.

In fact, managing knowledge from IT approaches are not limited. From what has been discussed above, it seems that thinking from IT technology is very popular when people start adopting Knowledge Management concept in construction industry. Similarly, Sun *et al* (1999) designed knowledge-based Collaborative Construction Information Network (CCIN) which supports collaborative information search and retrieval for construction related topics. Orange *et al* (2004) proposed COLA (Cross Organisational Learning Approach) information system which supports pre-review event, review event and post-review event activities, the database holds the descriptive information on the problems and issues arise in construction projects. Further more, Woo *et al* (2004) noticed the tacit dimension of knowledge in AEC organizations and proposed Dynamic Knowledge Map to exchange expertise. But they recommend further test of suitability of Dynamic Knowledge Map for tacit knowledge utilization in AEC organizations.

Following experimental research in SMEs in construction industry, Lee *et al.* (2005) simplify the challenges faced in the knowledge capture process in construction industry as:

- Technology; Weak in specialised range of technological competencies, no advanced or innovative technologies are roped in to help in the process.
- Organization; Lacking of awareness of Knowledge Management strategies and instruments

- People; Communication barrier when dealing with people.

Lee *et al.* (2005) suggested an Event Database mainly consisting of Audio Diary. They consider that this database will enable project information to be captured, retained, indexed so that people external to the project can retrieve and apply it to future tasks/projects. Though Lee *et al.* (2005) noticed the problem in transforming information to knowledge, they did not work out a solution for that, they still presume that once people access information they have retrieved knowledge.

In fact, managing knowledge by IT supported database is not a new concept, no matter how it is designed. An overall database for the construction industry has been proposed and designed more than 10 years ago. Based on the concept that competitive advantages increase with exploitation of knowledge, the UK Department of the Environment (DOE) established Industry Knowledge Base for construction industry in 1995 following the call for changes in the Latham (1994) and Egan (1998) reports. The objective of the Industry Knowledge Base (IKB) is to create and exploit information and knowledge to improve the effectiveness of the building industry. Specific objectives are:

- To improve the quality and efficiency of buildings and building projects by sharing information on standards and best practice.
- To improve the efficiency of the construction market by improving market communications.
- To reduce the cost and improve the quality of building design by sharing design knowledge.
- To provide news and information that will enable the construction industry to compete (Amor *et al.*, 1996)

But Amor *et al.* (1996) point out the problems for the electronic knowledge base as:

- Information Overload: too much information turn up when searching, time consuming and too much irrelevant information.

- **Domain Independent:** there is no distinction between the various domains in searching results. This can produce surprising results for searches for terms in very specific areas.
- **Islands of Information:** difficulties to integrate all areas of required information into a single point.
- **Information Validity:** the quality and accuracy of information, and the competence of the organization which put it together
- **Editorial Competence:** The ability to retrieve small segments of information when searching for information loses the context in which the information would be couched if found in a paper publication.
- **Structure of Object Libraries:** Lacks of industry-supported standards exist for the specification of component parameters, and no standard method of encoding this information has been adopted.
- **Security of Information:** many firms would be concerned about exchanging sensitive information electronically.

Nevertheless, these criticisms have failed to draw enough attention for further development of Knowledge Management design. All of these existing frameworks focus their attention on IT support within Knowledge Management. Though they take into account the tacit and social dimensions in Knowledge Management in the construction industry, they merely regarded these issues are a normal element of application context rather than the most critical issues which will lead to Knowledge Management failure if not managed properly. From the viewpoint of this research, these are two critical issues in distinguishing information management and Knowledge Management.

Tacit knowledge is deeply implicit in each individual's actions and experiences, as well as in the ideals, values, and emotions that they embrace or exhibit. Tacit knowledge is often hidden and cannot be represented easily, not even by electronic mechanisms (Martensson, 2000). It maybe asserted that the tacit dimension is a

critical element to distinguish information from knowledge. As discussed in the previous chapter, the social dimension and tacit dimension are essential for managing knowledge. Failure to manage these two key issues will halt Knowledge Management at the information management stage. This also supports the distinction made in this research between information and knowledge: knowledge can become information and people communicate information rather than knowledge, whether knowledge is exchanged in communication depends on whether people can generate meaning from the information. Thus knowledge becomes information once it is stored by an IT infrastructure, and can become knowledge again only when people can understand and use it in working practice. The existing framework's emphasis on IT captures Knowledge Management within information management, and fails to address how to restore information as knowledge, presuming that people will get knowledge once they get the information. Not surprisingly, all the frameworks mix the two concepts, "information" and "knowledge", in their statements. In reality, people need assistance in transferring received information to knowledge, and this step is most important. For example, schools and universities use examinations to check if the received information in classroom becomes knowledge in the students. They cannot presume students have obtained knowledge by walking into a library and reading some books.

To illustrate this concept, Nonaka and Takeuchi (1995) suggest that explicit knowledge can be transformed into tacit knowledge by socialisation, externalisation, combination and internalisation. All the existing frameworks discussed above fail to discuss how to socialize, externalize, combine and internalize information into knowledge, though they tackled the problem how to how to transform knowledge into information and store it with the help of IT support. McDermott (1999) points out that IT tools alone cannot effectively perform knowledge conversion, unless certain other conditions such as trust, face-to-face contact, time to interact between participants and creation of a common language are in place. Kogut and Zander (1992) have argued that the transferability of knowledge between organisations is shaped by two important parameters: the degree of codification and complexity. Considering these

parameters, it appears that not all knowledge can be transferred into information; the process of transferring information into knowledge needs effort, and such efforts have been ignored in those frameworks. Knowledge is embedded in people, and knowledge creation occurs in the process of social interaction (Sveiby, 1997). The existing models ignored the fact that the knowledge transfer process is ultimately a human-to-human process that is inherently interactive and dynamic (Egbu *et al*, 2005). The overwhelming emphasis on information technology (IT) and less about people (Scaborough, 1999) has not changed, and the reasons could be concluded to be the lack of a proper means of solution. Though Egbu (2001) considered the important mechanisms for sharing and transferring tacit knowledge include communities of practice (CoP), networking, story telling, coaching, mentoring and quality circles; he didn't point out that all of these activities are social networking activities to help knowledge sharing. However, he did not go so far as to consider this from social capital and social network perspectives. Social Network Analysis, with its emphasis on people's interactive relationships, is proposed therefore as a solution for the problem of lack of attention to people in Knowledge Management.

In general, all the models presented in this section are about how to manage knowledge within an organization. In today's business development, knowledge intensive organizations have to operate in a variety of circumstances, such as construction projects. New theories and models about Knowledge Management between organizations are developed for business practice. As the complexity of technology is increasing and the fragmentation along technology clusters is becoming unavoidable, know-who is becoming more important than know-how in industries such as the construction industry.

## **Summary**

This chapter reviews basic concepts and frameworks about Knowledge Management, but these frameworks are generally limited to intra-organizational management. Some basic concepts such as data, information and knowledge are discussed, followed by examples of current Knowledge Management frameworks to provide a basis to further discussion. The distinctions between data, information, tacit knowledge and explicit knowledge are redefined after review of previous research. A knowledge transfer process is proposed, based on the distinct concepts of data, information and knowledge. All of the discussions so far remain in the domain of a single organizational context. But as from a network perspective, the complexity of technology is increasing and the fragmentation along technology clusters is becoming unavoidable, *know-who* is becoming more important than *know-how* in the construction industry. Therefore, people must contribute their expertise along with Supply Chain across organizational boundaries. The discussion of knowledge contribution across organizational boundaries will be discussed later based on reviews of business network and social capital, thus, from a Social Network Analysis approach.

## **Chapter 3 UK construction development and management**

This chapter reviews the UK construction industry in its historical context. Starting from its early development, this chapter explains how this industry has adapted to its current situation and where the pressures for change have come from. Firstly the management methods, including transaction costs, Concurrent Engineering, quasi-firm and temporary multi-organizations, Supply Chain and supply network are reviewed. Secondly, this chapter reviews existing management methods in construction projects in attempting to answer the question of “how to change” under pressures of change. The emerging method of partnering as collaborative working, which is a major focal point of this research, is to be discussed in the end of the chapter.

### **3.1 The development of the British construction industry**

Construction projects are complex and require the involvement of a large number of actors-e.g. client, architect, lawyer, consultant, equipment supplier, construction worker, building commissioner, etc. Typically, construction projects are achieved by temporary coalitions of firms who relate through subcontracting and other means (Sorrell, 2003).

The contractual structure depends on the procurement route, but increasing technical complexity and the desire for risk transfer has led to main contractors to prefer to use subcontracting rather than bear the risk of employing staff directly (Gann, 2000, p.

167). Evbuomwan & Anumba (1998) regard fragmentation as the main feature of construction and they conclude the following problems and consequences:

- inadequate capture, structuring, prioritisation and implementation of client needs;
- the fragmentation of design, fabrication and construction data, with data generated at one not being readily re-used downstream;
- development of pseudo-optimal design solutions;
- lack of integration, co-ordination and collaboration between the various functional disciplines involved in the life-cycle aspects of the project;
- lack of true life-cycle analysis of projects (including costing, maintenance, etc.);
- poor communication of design intent and rationale, which leads to unwarranted design changes, unnecessary liability claims, increase in design time and cost, and inadequate pre- and post-design specifications.

The traditional practice in UK construction has been to select contractors on the basis of lowest price. Traditionally the UK construction industry has used a “professional system” (Winch 2000), in which clients rely on consultants to carry out design and financial monitoring, a main contractor takes overall responsibilities for production of the building to a design and specification. Professionals’ organizations including Architects (RIBA), Engineers (ICE, ISE, CIBSE) and Quantity Surveyors (RICS) select entrepreneurial contractors by competitive tendering. This traditional procurement system has prevailed for most of the 19th and 20th centuries. Despite its emphasis upon lowest price, competitive tendering doesn’t necessarily deliver low production costs; in addition, it also generates very high transaction costs. Consequently, the professional system later become a “low-trust” system in which all actors spent a growing proportion of their time “covering their rear” rather than moving forward (Winch 2000).

In the 1960s, alternatives to the professional system began to be tried in Britain. A new form of procurement known as “management contracting” was imported from the USA. A second major difference was a shift towards selective, rather than open



competitive tendering.

Tendering results in contracts being detailed and complex, and low trust; adversarial relationships are the norm. Traditionally, contractors are selected through competitive tender on the basis of lowest price, and there is little communication between the parties involved. Fierce price competition and low margins create an incentive for the winning contractors to cut costs (Winch, 2000). This leads to the use of oversight and control mechanisms, such as quantity surveyors, to reduce the risk of opportunistic behaviour (Winch, 1989) because contractors have strong incentives to maximize their margin by making claims or taking advantages of design changes after bidding hard for the contract. In general, the industry is characterised by low and unreliable profitability, limited investment in R&D, and persistent skill shortages (Sorrell, 2003)

Having noted the above problems, two important government reports called for fundamental reform in the UK construction industry, namely : Constructing the Team, (or the “Latham Report”; Latham, 1994); and Rethinking Construction, (or the “Egan Report”; Egan, 1998), some policy initiatives followed the two reports for construction reform, the major changes being in procurement systems and project management structures.

The construction industry in the UK was characterised as very slow to respond to pressure for change in the past (Latham, 1993). Latham’s report points out that “there is no value to the client in accepting an uneconomic or unrealistic tender which has been submitted by a contractor desperate for work. The work may suffer in standards or performance. The contractor may seek to bolster the low tender through financial pressures...on subcontractors...[or]...possible later claims...Where the money is inadequate, vital trust will be absent and the project will always suffer through lack of team work and adversarial attitudes. No one will benefit, least of all the public interest” (Latham, 1993, p15)

In his first report, Latham (1994) calls for a need to change in order to find a solution for better performance, but with fairness to all. This report also emphasises teamwork by adopting NEC form of contract because “endlessly refining existing conditions of contract will not solve adversarial problems”. Win-win partnering were offered as including new strategies for the UK construction industry, and these lead to new procurement system and new management practice.

The main conclusions from Latham’s report (1994) are:

- Clients are the key to project performance and they should come together in a Construction Clients Forum.
- Tendering procedures for both consultants and contractors are in need of reform and should both be developed to include quality as well as cost criteria in tender evaluation.
- Existing standard forms of contract are inadequate and generate adversarial relations. New forms of contract need to be established, and the New Engineering Contract is recommended as a model. These standard forms should also be given statutory backing.
- A target of a 30% reduction in construction costs should be set for the year 2000.

Following Latham’s report, Egan (1998) noted that the construction industry is largely fragmented with over 160 000 individual firms

Egan (1998) points out:

*‘The Task Force sees the industry dealing with the project process as a series of sequential and largely separate operations undertaken by individual designers, inspectors and suppliers who have no stake in the long term success of the product and no commitment to it. Changing this culture is fundamental to increasing efficiency and quality in construction...the efficiency of project delivery is presently constrained by the largely separated processes through which they are generally planned, designed and constructed. These processes reflect the fragmented structure of the industry and sustain a contractual and confrontational culture. This process may well*

*minimise the risk to constructors by defining precisely, through specifications and contracts, what the next company in the process will do. Unfortunately, it is less clear that this strategy protects the client'* (Egan, 1998, p.16, p.22)

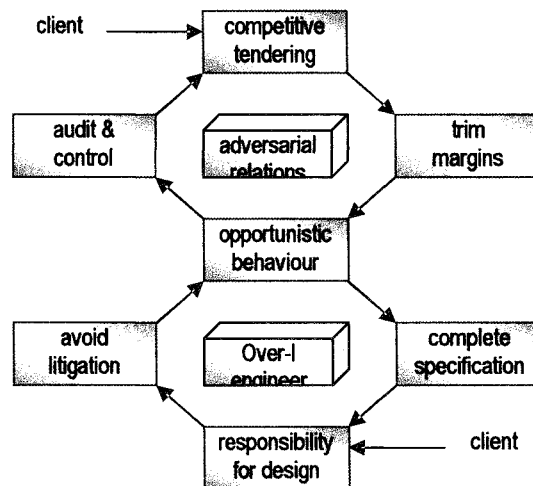
Facing the problems arising from fragmentation, Egan (1998) considers that “the most successful enterprises do not fragment their operations ... The process and the production team are then integrated to deliver value to the customer efficiently and eliminate waste in all its forms. The Task Force has looked for this concept in construction and sees the industry typically dealing with the project process as a series of sequential and largely separate operations undertaken by individual designers, constructors and suppliers who have no stake in the long term success of the product and no commitment to it. Changing this culture is fundamental to increasing efficiency and quality in construction.” (Construction Task Force, 1998: 2:17)

The two reports (Egan, 1998; Latham, 1994) point out that the UK construction industry should improve its capital cost, product quality, and client satisfaction to come up with European countries. Also their reports highlighted the importance of collaborative working to achieve better, more innovative construction projects performance. Long term partnering and collaborative working are advocated because “alliances offer the co-operation and continuity needed to enable the team to learn and take a stake in improving the product. A team that does not stay together has no learning capability and no chance of making the incremental improvements that improve efficiency over the long term. The concept of the alliance is therefore fundamental to our view of how efficiency and quality in construction can be improved and made available to all clients, including inexperienced ones... Partnering on a series of projects is a powerful tool increasingly being used in construction to deliver valuable performance improvements. (Rethinking Construction 'The Egan Report' (Construction Task Force, 1998, p4, p67). Therefore, “the industry must replace competitive tendering with long term relationships based on clear measurement of performance and sustained improvements in quality and efficiency”

From management theory, Frubotn and Richter (1997) conclude that the above problems arise for the following reasons:

- **Bounded rationality:** Individuals are assumed to be intendedly rational, but subject to severe constraints on their time, attention and ability to process information (Simon, 1959). Decision-making relies heavily on routines and rules of thumb, and contractual arrangements are unable to cover all contingencies.
- **Opportunism:** Self-interested individuals are assumed to act opportunistically to achieve their ends, including lying, cheating and deliberately distorting information. The scope for this will depend upon the asymmetry of information between different parties to a contract.
- **Transaction costs:** Transaction costs exist because of attempt to resist the adverse potential effects of Bounded rationality and Opportunism. They are assumed to be inherent in all contractual relationships, whether organised through markets or internal to organisations. These include the costs of searching for and obtaining information, the costs of bargaining and reaching decisions, and the costs of monitoring and enforcing contracts. Transaction costs depend upon both the nature of the transaction and the associated legal, organisational and institutional arrangements.

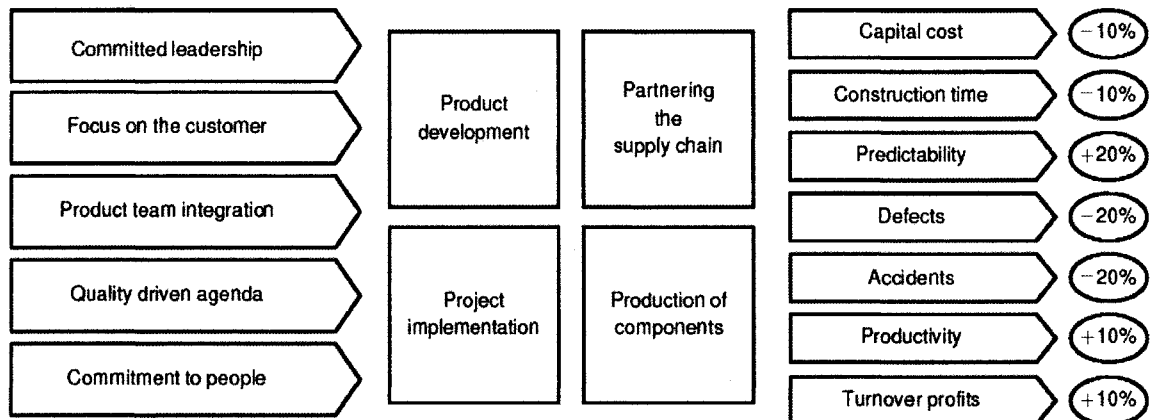
Winch (2000) represents the adversarial relationships in project teams in traditional procurement system in a dynamic interactive model shown below:



*Figure 3.1 The dynamic of adversarial relations and overengineering*

(Adopted from Winch, 2000)

Therefore, Egan (1998) recommends integration of project parties in construction process, known as “partnering”. He proposes the following reform aims:



*Figure 3.2 The Egan 5-4-7 agenda*

(Adopted from Egan, 1998)

Partnering and the reform of standard contracts focus on transaction governance, where by reducing transaction costs, important gains can be made as costs are reduced; differences are resolved before they become disputes, and disputes can be settled

without expensive litigation. However, an important additional benefit of partnering is that it can provide the motivational context for innovation, and hence a direct attack on production costs. The vicious circle of audit and control set up in the competitive tendering process largely removes the incentive for tenderers to offer alternative ways of meeting client needs (Winch, 2000).

New procurement systems have been developing along with the discussion of the above problems. New management methods have been proposed and tried. Masterman(1992) suggests that “procurement systems” relate to “methods and organisational structure”. Furthermore, Franks (1998) defines a procurement system as “an amalgam of activities undertaken by a client to obtain a building”. From these suggestions and definitions it is clear that organizational management in construction industry is tightly related to procurement systems research.

This section reviews development of the UK construction industry to provide updated information about its current situation and its origins. It explained why the UK industry developed into a situation and what the needs for change are. The following sections will review managerial implications. Based on the already specified research direction, this review focuses on governance structure and participants relationships in construction project. There are numerous management methods in construction industry, some of them, such as TQM in construction, performance measurement, are not reviewed due to their less influences.

## **3.2 Managing projects in construction**

After reviewing the development of the UK construction industry, the problems and the transforming situation are explained in their historical context. The review has answered “why this situation” in assessing the UK construction industry development,

and the following section reviews management methods adopted in construction practice in order to answer the question of “how to manage”. It reviews the importance of concepts such as transaction costs, quasi-firms/temporary organizations, Concurrent Engineering and Supply Chain management. All of these concepts are concerned with organizational relationships between project parties. This relationship assessment is an important issue in this research.

### **3.2.1 Transaction costs**

Bennett (1991) noted that research in project management has been concerned mainly with process and technique. He concluded that the latter aims at increasing efficiency, the former is concerned with increasing understanding why construction projects are organized with particular configurations and how best to design them.

Transaction cost economics can contribute to these and allow an examination of the relationship between a systems approach to organizations and a transaction cost approach to markets and hierarchies to establish whether each enriches the other to further consolidate project management theory (Walker and Lim, 1999).

The 1991 Nobel Prize Winner of Economics, Ronald Coase, considered that neoclassical economic analysis assumes that economic activities can be co-ordinated costlessly by a system of prices. Transaction cost economics recognizes that there are costs of using the pricing system and that such costs give rise to various forms of economic organizations (Coase 1988). The famous Coase theorem states that all value that can be created from the exchange and use of an economy’s available goods will, in fact, be created when transaction costs are absent.

Williamson (1981) suggests that a transaction occurs whenever ‘a good or service is

transferred across a technologically separable interface'. To understand transaction cost theory, Williamson uses the metaphor of friction to explain:

With a well-working interface, as with a well-working machine, these transfers occur smoothly. In mechanical systems we look for frictions: Do the gears mesh, are the parts lubricated, is there needless slippage or other loss of energy? The economic counterpart of friction is transaction cost: Do the parties to the exchange operate harmoniously, or are there frequent misunderstandings and conflicts that lead to delays, breakdowns, and other malfunctions? (1985, pp. 1–2). The zero-transaction-cost social world can then be compared to a frictionless physical world. 'Transaction costs are the economic equivalent of friction in physical systems' (1985, p. 19).

To explain the working interface, Winch (2001) suggests that: A technologically separable interface is one that is not constrained by the nature of the production technology – in other words, the production technology chosen does not foreclose the possibility of allocating two different parts of the production process to different parts of the organization, or to separate organizations. The fundamental insight of the transaction cost approach is that in order to economize on the total cost of a good or service, both production costs and transaction costs must be taken into account. Thus total costs are the sum of the costs of production and the cost of governing the transactions inherent in that choice of production technique. A production technique that has the lowest production costs might not be the economizing choice if transaction costs are also taken into account....The transaction cost approach takes the economics of production as read: it regards them as important, but already well understood. It focuses, instead, on understanding the drivers of transaction costs"(p.799).

According to Walker and Lim (1999), the transaction cost analysis approach emerged from the seminal work of the economist Coase (1937) in which he advanced his theory of the existence of firms. Coase (1991) suggests that in the absence of



transaction costs, there is no economic basis for the existence of the firm. Coase (1991) argued that 'a firm could only continue to exist if it performed its co-ordination function at a lower cost than would be incurred if it were achieved by means of market transactions and also at a lower cost than this same function could be performed by another firm'. They are performed without error and costlessly, as if by a free and perfect computer. The real tasks of management, to devise or discover markets, products, and production techniques, and actively to manage the actions of employees, have no place in the perfect decentralization model because it assumes that all products, markets, production techniques, and prices are fully known at zero cost' (Walker and Lim 1999). Therefore, businessmen in deciding on their ways of doing business and on what to produce have to take into account transaction costs. In fact, a large part of what we think of as economic activity is designed to accomplish what high transaction costs would otherwise prevent (Coase 1992 p.716).

Williamson (1975, 1985) has advocated transaction-cost theory based on these concepts discussed above. Williamson (1981) considers that the transaction cost approach has been applied at three levels of analysis.

- the overall structure of the enterprise which asks how the operating parts are related to one another; a direct reflection of the systems approach to organization design.
- the operating parts and activities performed within and outside of the firm and reasons
- the manner in which human assets are organized to match internal governance structures.

Williamson also characterises transaction cost theory with three dimensions, which are "uncertainty, the frequency with which transactions recur and the degree to which durable transaction specific investments are incurred (1979: p.239)"

In applying transaction cost analysis, Winch (1988) considers a socio-technical

systems approach. Winch (1988) argues that all organizations have a technical system comprising of work processes serviced by the social systems of personal and group interaction. In construction, these systems operate within single organizations but also across the boundaries of the firm. Winch (2001) also concludes the following three key elements in transaction cost theory:

- contingency factors, i.e. the features of the transaction under consideration, which are uncertainty, frequency and asset specificity;
- behavioural factors, i.e. the ways in which managers typically respond to those features, namely bounded rationality, learning and opportunism, respectively; and
- context, originally called ‘atmosphere’ by Williamson, i.e. the institutional context within which the transaction is embedded, which in turn is situated within the broader national socio-cultural context.

Among the three elements, the behavioural assumptions underpinning transaction cost economics, particularly opportunism, moral hazard and shirking are inconvenient concepts for management theorists to accept. Williamson (1975) suggests that information imperfectness is “a derivative condition that arises mainly because of uncertainty and opportunism, though bounded rationality is involved as well. It exists when true underlying circumstances relevant to the transaction, or related set of transactions, are known to one or more parties but cannot be costlessly discerned by or displayed for others.” (Williamson, 1975 p.31). Alchian & Woodward (1988) refer the lack of observability of contingencies and the consequence of hidden, unverifiable action within contractual relationships as “moral hazard”.

The recognition of opportunism and moral hazard demonstrates that transaction cost economics clearly recognizes behavioural phenomena as having a strong influence on organizational effectiveness, but does so for the purpose of generating refutable implications rather than an intrinsic theoretical explanation. In practice, the examination and integration of behavioural elements could explain the configuration of project organizations and how they perform (Walker and Lim. 1999).

The third element, context or atmosphere, is business environment in which organizations operate. Due to complexity and uncertainty in business environment, information is unevenly distributed (information imperfectness) and certain parties could take advantages from the market transaction (Winch 2001).

Duncan (1971) suggests some components which construct the business environment

<p>Internal environment</p> <p>Organizational personnel component</p> <p>Educational background and skills</p> <p>Previous managerial skills</p> <p>Interpersonal behaviour skills</p> <p>Availability of manpower for utilization within the system</p> <p>Organizational functional and staff units component</p> <p>Technological characteristics of organizational units</p> <p>Interdependence of organizational units in carrying out their objectives</p> <p>Conflict among organizational, functional and staff units</p> <p>Organizational level component</p> <p>Organizational objectives and goals</p> <p>Nature of the organization's product/service</p>
<p>External environment</p> <p>Customer component</p> <p>Distributors of product or service</p> <p>Actual users of product or service</p> <p>Suppliers component</p> <p>New materials suppliers</p> <p>Equipment suppliers</p> <p>Labour supply</p> <p>Competitor component</p> <p>Competitors for suppliers</p> <p>Competitors for customers</p> <p>Sociopolitical component</p> <p>Government regulatory control over industry</p> <p>Public political attitude towards industry and its particular product</p> <p>Relationship with trade unions</p> <p>Technical component</p> <p>Meeting new technological requirements in production of products or services</p> <p>Improving and developing new products and methods</p>

*Table 3.1 Factors and components comprising the organization's internal and external environment*

(Adopted from Duncan, 1971)

These internal and external elements construct the uncertainty and complexity of the environment, along with bounded rationality in agency, transaction cost arises from market imperfectness and internal competition, or from in pursuit of own goal rather than those of the overall organization (Winch 2001).

Though Winch's transaction cost approach generates fruitful analysis, some issues remain untouched in construction industry. For example, Buckley & Enderwick (1989) point out that the specification of the organizational structure is missing in a transaction cost analysis of construction firms.

Walker and Lim (1999) consider the organizational structure selected in a construction project should aim to minimize transaction costs. Before this can be achieved an understanding is needed of how transaction costs arise. Many transaction costs arise from preparing and enforcing contracts and procedures designed to produce behaviour on the part of members of project organizations which is compatible with project objectives. However, there is a risk that such behaviour is not compatible and not controlled, the cost of which can also be conceived as a transaction cost (Walker and Lim. 1999). Their research identified the transaction cost through clients' viewpoint and discussed how to minimize that:

- the costs of setting objectives, integrating contributions,
- making the various managerial decisions and
- controlling the contributors, costs which arise from the organization structure selected

By reference to transaction cost economics analysis, Walker and Lim (1999) argue that the choice of a structure is a result of the relative costs of specifying the nature of the project arising from different structures and depending on the type of project. The cost of managing the process of project specification and the actual detailed specification are transaction costs. The management activities required to achieve these are defined by project management theory. However, the project management costs are entirely transaction costs and that the role of project management is to minimize the total of transaction and production costs; a situation which has the potential for conflicts of interest.

### **3.2.2 Quasi-firms and temporary organizations**

Eccles (1981) argues that bounded rationality and uncertainty/complexity are both a partial result of a common set of factors. Considerations of these factors have led to debate over subcontracting and vertical integration. Eccles (1981) points out the unbalanced views in transaction cost theory while Williamson emphasizes how hierarchical transactions can reduce risks, he pays less attention to how market transactions could reduce risks.

In academic research and practice, the markets and hierarchies framework in transaction cost theory has been used to explain the different means by which organizations manage their internal and external relationships and coordinate their activities. According to Williamson (1981) hierarchy refers to the conventionally conceived formal organization or firm. People are directly employed, exchanging their labour power and their willingness to submit themselves to the authority of their employers for payment and for the satisfactions that stable working relationships may bring. In this situation, coordination can be effected on the basis of unified authority. In contrast to this arrangement, coordination can also be achieved by independent individuals or firms, entering into exchange relationships through the market, as and when it suits them. The suitability of markets or hierarchies as forms of coordination can, in principle, be calculated in terms of transaction costs. Based on transaction cost theory, Eccles (1981) proposes the quasi-firm framework to explain a situation in which firms form market transaction but they are hierarchical transactions in essence. It shares similarities with “inside contracting system” (Williamson 1975) in its market and hierarchy continuum in transaction cost theory. The difference is that this is “outside contracting” but firms act like they are in one organization, it integrates both features from two ends of hierarchies-markets continuum. Eccles (1981) suggests that the term of “quasi-firm” could be used to explain stable relationships between a main contractor and a set of subcontractors.

Eccles considers that characteristics in construction technologies result in a “preferred contracting mode intermediate between bilateral and unified governance structures when certain environment conditions exist(1981, p.337)”, and the general contractor has strong incentive to subcontract certain trade specialist organizations extensively. The relational contracting mode emerges when main contractor continues working with certain subcontractors from project to project. This could eliminate the opportunism discussed in transaction cost approach; subcontractors have continuing commitment over project durations. The continuing association enables both parties to benefit from “the somewhat idiosyncratic investment of learning to work together”, suggests that the characteristics of construction technology enable recurrent transactions between a general contractor and subcontractors. Both parties benefit from a bilateral structure over a market structure but cannot prohibit the costs of the market structure alternatives. He considers that the quasi-firm is intermediate between bilateral and unified structures; also it is intermediate between relational and neoclassical contracting. Quasi-firm is an advantageous governance structure due to its stability and recurrence. In extreme cases, certain subcontractors work exclusively for one main contractor which largely reduce risks from market transactions.

Eccles is correct in pointing out that the ‘market’ and ‘hierarchy’ concepts are not so distinctive in certain situation in construction practices. Whilst the transaction cost and quasi-firm literature has been concerned with firms and relationships, the project organization as a temporary multi organization (Cherns & Bryant 1984) is noticed as the economy of its co-ordination function. Theories on temporary organizational settings (e.g., projects) are much less prevalent while mainstream organization theory is based upon the assumption that organizations are or should be permanent (Lundin& Soderholm 1994).

The temporary multi organization is defined as an organizational structure consisting of individual elements in the nature of a conglomerate (Cherns and Bryant, 1984). For Cherns and Bryant (1984), the two most important aspects of the industry are customer specificity of the "final product and the involvement of numerous

value-adding organisations. In explaining the nature of the temporary organization, Lundin & Soderholm (1994) consider that action has a leading role in developing "a theory of the temporary organization" while theories of the firm are often based upon the notion that decision-making is at the core of the organization. Lundin & Soderholm (1994) provide two reasons for "action leading" theory rather than "decision making leading" theory. The first reason is that other research shows that actions may not in fact be a consequence of decisions. Decisions can be made after actions, and that they may be made to legitimize actions already taken. In addition, solutions may be implemented even without there being any problem attached to them (Jonsson and Lundin, 1976). There even may not be any logical connection between decisions and actions. The second reason for adopting action as a primary concept in a theory of temporary organizations, is that temporary organizations are almost always motivated by a need to perform specific actions (Miles, 1964, p. 443; Goodman and Goodman, 1976, p. 494; Goodman, 1981, pp. 2-4) in order to achieve immediate goals (Palisi, 1970). If temporary organizations are being discussed as systems for implementation, action is also an important feature (cf. Lundin & Soderholm, 1994; Borum and Christiansen, 1993). Therefore, the temporary multi organization theory is action based in essence.

In defining temporary organizations, Lundin & Soderholm also (1994) propose four basic concepts - time, task, team and transition—that are used in the description or classification of any temporary organization and its environment. The concepts differ from the crucial concepts that define the permanent organization. Permanent organizations are more naturally defined by goals (rather than tasks), survival (rather than time), working organization (rather than team) and production processes and continual development (rather than transition).

- Time. As "temporary" implies something that exists for a limited time. Time is used in such organizations in a linear form, to lead the way from a starting-point to termination. In order to explain action in temporary organizations, time as a sequence or as phases becomes important. Crucial problems must be handled in

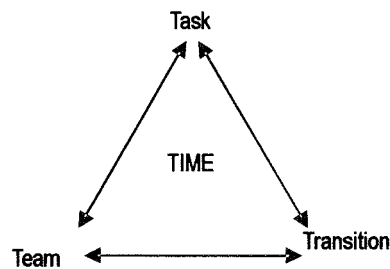
limited period and time has to be considered as scarce resources. Thus, temporary organizations provide a highly organized way of dealing with time problems and of acting according to the perception of time as being scarce, linear and valuable

- **Task.** A task legitimizes a temporary organization and can be compared to a permanent organization's devotion to goals. While goals primarily provide a focus for decision-making, a task focuses on action. Task-related activities are of major importance in the development of temporary organizations. In most cases, in fact, the creation of a temporary organization is motivated by a task that must be accomplished. that it represents the main motivation for the creation and development of a temporary organization. The formulation of tasks and a definition of their properties (including judging whether they are repetitive or unique) and their limits, is a social process which involves those who are participating in the temporary organization as well as knowledge gathered from "outside" and/or general experience in the field.
- **Team.** Any temporary organization needs to be designed by and around people. Temporary organizations are naturally also dependent on the will, commitment and ability of individuals for their creation, development and termination. The team concept could be viewed from angles: (1) the relation between individual(s) and the team and (2) the relation between the team and its environment. In the first case that commitment-building is of central interest, while legitimization is a key element in the second.
- **Transition.** An action orientation implies that something has to be transformed or changed as a consequence of the existence of the temporary organization, and that these changes are to be achieved before the organization is terminated. By emphasizing transition, temporary organizations can represent one way of overcoming the inertia normally found in permanent organizations. By creating a "new" setting for action, transition may be seen as something that is important and relatively easy to achieve (Lundin& Soderholm 1994).

According to Lundin & Soderholm's explanation, the time, task, team and transition



aspects of the temporary organization are related to each other: the definition of a task may put limits on time; likewise, time limits may disqualify certain tasks. Task definition also implies aspirations about transition, and some of these may also select or define the task. Team members may be selected in light of how the task is defined. If the team is organized before the task has been finally defined, then team members and their competencies will influence what task or transition aspirations may be proposed. Time limits are dependent on the transition aspiration connected with the temporary organization, but at the same time it is possible that the time limit defines the type of transition that is feasible. These general connections between the basic concepts are illustrated below. Time is in the middle to emphasize its role as the most important of the basic concepts.



*Figure 3.3 Interrelatedness of the basic concepts in the theory of temporary organizations.*

(Adopted from Lundin & Soderholm, 1994)

Though Lundin & Soderholm (1994) provide some instances to illustrate their theory, it is not readily adaptable to construction projects in business practice. In the complex reality, construction of economical incentives and relational development are important issues, but are discussed lightly in this framework. Also, it would be more appropriate to position *task* rather than *time* at the centre of the model.

### 3.2.3 Concurrent Engineering

Following of the need for change within the construction industry, particularly with project processes, many construction companies are responding corporation aspects of Concurrent Engineering (CE) practices to improve their project development capability (de Graaf and Sol, 1994). Simultaneously, construction companies are also trying to make their Supply Chains more effective, and more efficient. CE has the potential to make construction projects less fragmented, improve project quality, reduce project duration, and hence reduce total project cost, while creating more satisfied customers (Khalfan *et al*, 2001).

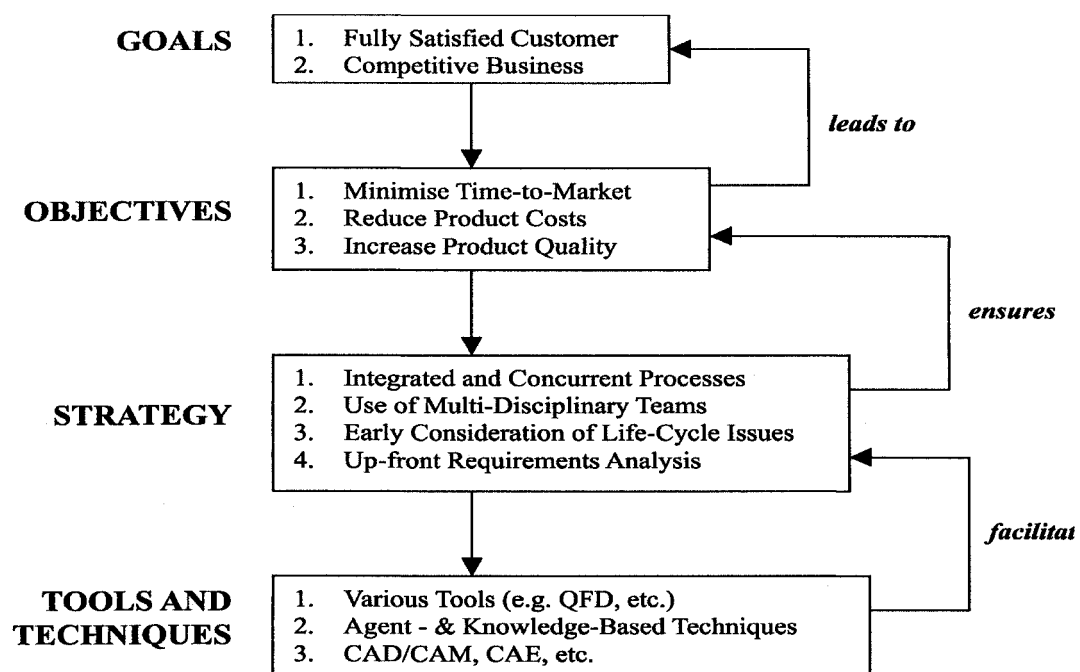
Originally, Concurrent Engineering (CE), sometimes called simultaneous engineering, or parallel engineering, is a management concept in responding to the need of reducing the time to develop and introduce new products in order to remain competitive. The concept emphasizes integration of complementary engineering expertise, cooperation of multiple competing perspectives, communication between upstream and downstream product life-cycle concerns, and coordination of group problem-solving activities (Krause, *et al* 1993).

Winner *et al.* (1988) define Concurrent Engineering as “a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements”

From the beginning, CE is designed to facilitate the simultaneous consideration of all project-related issues and processes from the conception stage. Two of the main features of CE are the use of systematic or parallel processes (instead of traditional sequential ones), and the use of multi-disciplinary teams comprising all parties

involved in the project, including the client and suppliers (Evbuomwan and Anumba, 1998).

For successful implementation of CE Brookes and Backhouse (1997) develop a CE framework which takes into all aspects of the production process in order to improve the product introduction process. This framework comprises the goals and objectives of the concept and project, the strategy to be used for carrying out CE (such as integrated processes and multi-disciplinary teams) and the supporting tools and techniques to be used. The CE framework developed by Brookes and Backhouse (1997) is presented below



*Figure 3.4 Concurrent Engineering frameworks*

(Adopted from Brookes and Backhouse, 1997)

In this framework, most of the supporting tools and technologies are computer-based and can be classified as those which relate to business processes and deal with team-working, leadership and organisational issues, and those which deal with the

design and production (or construction) processes (Kamara *et al.*, 2000)

Concurrent Engineering (CE) in construction is regarded as an management approach to overcoming problems caused by fragmentation of the functions from different participants, especially between design and construction teams (Anumba *et al* 2002). Jaafari suggests Concurrent Engineering (CE) as ‘concurrent construction’ (CC) in the construction industry, and defines it as ‘an integrated approach to the planning and execution of all project activities, from the conceptualization state through to the handover of the facility’ (1997:429).

Love and Gunasekaran (1997) suggest the following aspects are essential for concurrent construction

- The identification of associated downstream aspects of design and construction processes.
- The reduction or elimination of non-value-adding activities.
- The development and empowerment of multi-disciplinary teams.

The need for adopting Concurrent Engineering in construction is discussed by several publications which Yaung *et al* (2003) summarise as follows:

- It is a philosophy that can overcome the disadvantages of existing fragmentation and specialization in the construction industry if applied properly (De la Garza, *et al*, 1994).
- It is a schedule reduction tool that could reduce project delivery duration by 20-25% without an associated increase in project cost (Eldin, 1997).
- It is an approach imported from the manufacturing industry to assist in overcoming the construction industry’s poor productivity and performance (Love and Gunasekaran, 1997).
- Its application in a construction project tended to increase project delivery speed and project quality but do not have a significant impact on project unit cost (AbulHassan, 2001).

Khalfan *et al* (2003) argue that though Concurrent Engineering (CE) is gaining acceptance, some implementation efforts have not realised their full potential for reducing costs, reducing time, and increasing efficiency, effectiveness and performance for product development efforts. This is due in part to insufficient planning to support the implementation (Khalfan and Anumba, 2000). Khalfan *et al* (2003) suggest “CE readiness assessment” approach which has been used successfully to improve CE implementation planning in other industries. This approach is to assess an organisation and its Supply Chain participants prior to the introduction of CE because this helps to investigate the extent to which they are ready to adopt Concurrent Engineering practices (Compton and Byrd, 1996).

Khalfan *et al* (2003) conclude that CE readiness assessment tools and models have been developed and used in other industries such as the manufacturing and software engineering industries and compared their features

Tools/models → criteria\	RACE	PMO	PMO-RACE	PRODEVO	CMM	SPICE
Aspects covered	<i>Process</i> Customer focus. Product assurance. Leadership. Team formation. Strategy deployment. Agility. Teams within the organisation Process focus. Management system. Discipline.  <i>Technology</i> Project architecture. Application tools Communication. Co-ordination. Information sharing. Integration.	<i>Organisational environment</i> Task environment. General environment.  <i>Processes</i> Primary processes. Control processes. Control processes: <i>Strategic level.</i> <i>Adaptive level, and</i> <i>Operational level</i> Support processes.	Aspects covered are the same as PMO & RACE because this is the combination of both of these tools.	Customer & user focus Process focus Team & project focus Life-cycle perspective Communication	<i>Process</i> Pre-project phase Pre-construction phase Construction phase Post-construction phase  <i>Information Technology</i> Simulation Integration Intelligence Communications Visualisation IT support	Brief management. Project planning. Project tracking & monitoring. Contract management. Quality assurance. Project change management. Risk management. Organisation process focus. Organisation process definition. Training programme. Inter-disciplinary co-ordination. Peer review. Technology management
Status of tool/method	Commercial	Development ongoing	Development ongoing	Development ongoing	Commercial	Research prototype
Survey method	Questionnaire & interview.	Interviews, description of past and current projects, formal procedures and quality hand book	Questionnaire & interview.	Questionnaire.	Questionnaire & interview.	Questionnaire & semi structured interview.
Software availability	Yes, also uses other software (e.g. SPSS).	Can use any modelling software.	Yes	None.	Yes, but also use other software e.g. SPSS.	None.
Ease of use	Yes, but technological aspect is complicated to answer and is only for specialists.	Yes, but seemed to be incomplete, that's why merged with RACE later on.	Yes, and it seems to be completed after the combination of PMO & RACE.	Yes	Yes	Yes. MCQs are developed with additional space for comments.
Appropriateness for use in construction	Yes, but requires some modifications.	Yes, but basically used for analysing and designing an organisation, its process and technology.	Yes, but RACE model requires modification before applying to construction.	Yes, but it requires changes to address construction specifically.	Yes, but basically developed for software industry, therefore it requires changes before applying to construction.	Yes, but this tool is basically made for process improvement within construction projects.
Can be used for concurrent engineering readiness assessment	Yes, basically made for this purpose.	Basically used for analysing & designing organisations.	Yes, mainly for readiness assessment but also used for CE implementation process.	Basically developed for assessing concurrent engineering (CE) process.	Yes, but basically used for CE implementation process.	Basically used for process improvement.

*Table 3.2 Comparison of CE assessment tools in other industries*

(Adopted from Khalfan *et al*, 2003)

Furthermore, Khalfan *et al* (2003) developed CE assessment framework for

construction industry as the following CERAMconstruct model

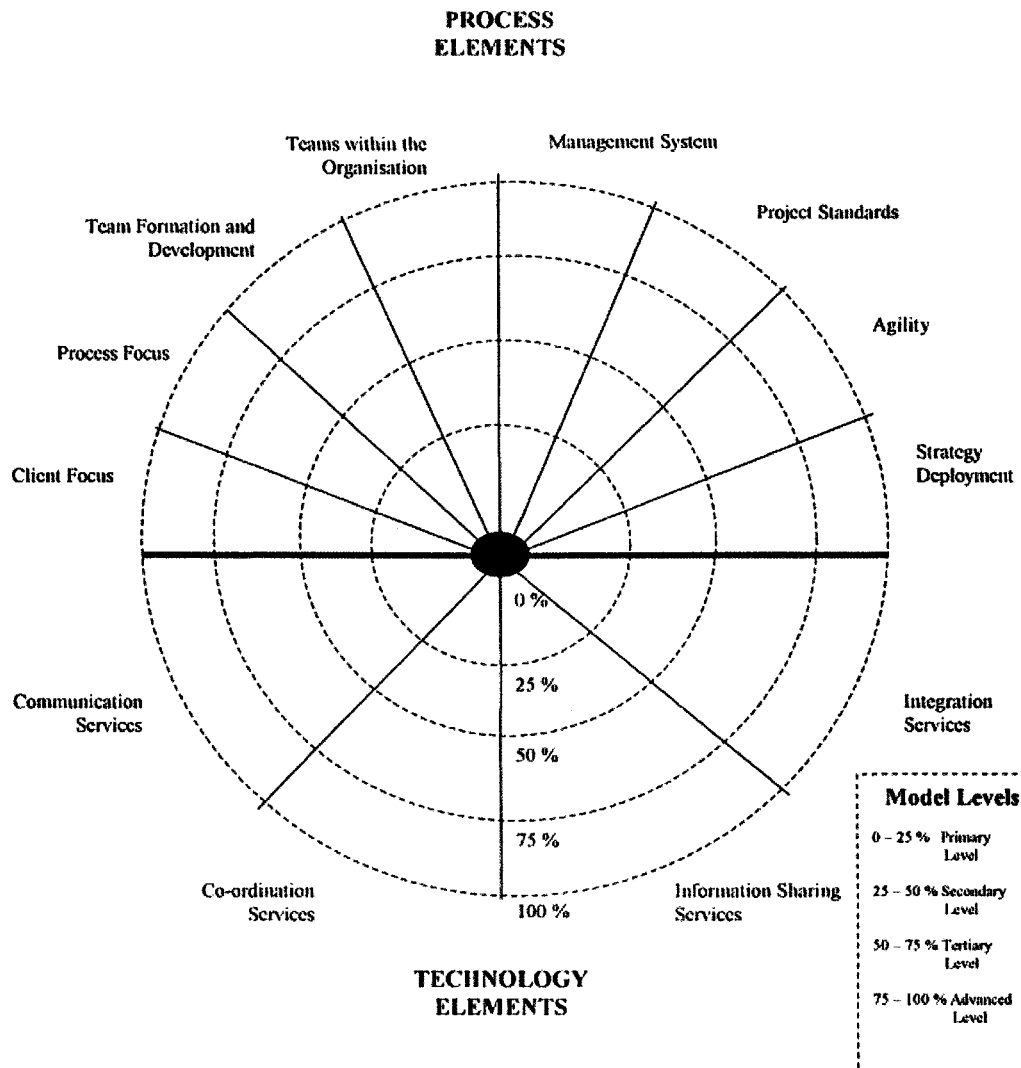


Figure 3.5 CERAMconstruct model

(Adopted from Khalfan *et al*, 2003)

Khalfan *et al* (2003) also developed a questionnaire based on this model (called the CERAMconstruct questionnaire) in order to assess construction organisations. The questionnaire has two basic assumptions:

- the various members of a project development team are part of a virtual construction organisation, which is involved in supervising the whole project development process from the inception until hand-over of the project.
- a virtual construction organisation could have more than one ongoing project, and

involve more than one team to design, construct and manage a particular project

The CERAMconstruct model is divided in two sections. According to Khalfan *et al* (2003), the upper half contains eight process elements used to assess the process maturity level of a construction organisation. The lower half contains four technology elements used to characterise the introduction and utilisation of advanced tools and technology within the organisation. For both process and technology elements, four levels have been defined which indicate the quality of the process and technology employed within the organisation. These four levels are primary level, secondary level, tertiary level, and advanced level. The primary level indicates that an organisation does not have any idea about CE practices or is not ready to adopt CE, whereas advanced level shows that the organisation is ready to adopt CE or is already practising CE within its project development process.

CERAMconstruct model is developed from that and other well established models, especially RACE model in manufacturing. The development of CERAMconstruct model is to meet special the needs of the construction industry. Khalfan *et al* (2003) consider that the CERAMconstruct will enable the construction Supply Chain to identify weaknesses within the Supply Chain with respect of CE implementation. Also it will facilitate the targeted CE implementation of CE within the construction industry.

### **3.2.4 Supply Chains and supply networks in construction**

While transaction cost economics mainly focus upon individual contractual relationships, Supply Chain theory aims to analyse interdependent relationships in business process. Under the trend of moving from an adversarial environment to one that is founded on collaboration, construction should openly embrace SCM (e.g.



Barker *et al*, 2000). Supply Chain Management (SCM) in construction industry was developed at end of last century; Vollman *et al* (1998) suggest that construction SCM should be seen as an integrated set of practices aimed at managing and coordinating the entire chain from raw materials to end customers.

According to Coyle *et al* (1996), the Supply Chain concept became an explicit area of research in the mid 1980s and originated largely from the two separate management streams of distribution and production, which merged into the field of logistics.

Billington (1994) points out that *Supply Chain* is a network of facilities that procures raw materials, transforms them into intermediate subassemblies and final products and then delivers the products to customers through a distribution system. A Supply Chain can be defined as three or more organizations directly linked by one or more of the flows of products, services, finances, and information from a source to a customer (Mentzer *et al.*, 2001). It is a group of firms that work in a coordinated manner in procuring raw materials and components, manufacturing a product from these materials, and delivering a finished product to a customer (Reddy and Reddy 2001). Most researchers in this field use the definition that a Supply Chain is the set of entities involved in new products and services, procuring raw materials, transforming them into semifinished and finished products, and delivering them to the end customer (Swaminathan, 2001).

Similarly, Ross (1998) considers that “Supply Chain management is a continuously evolving management philosophy that aims to unify the collective production competencies and resources of the business functions found both within the enterprise and outside in the firm’s allied business partners located along intersecting supply channels into a highly competitive, customer-enriching supply system focused on developing innovative solutions and synchronizing the flow of marketplace products, services, and information to create unique, individualized sources of customer value” (Ross, 1998). He considers that Supply Chain could be analyzed at two levels;

strategic and tactical levels. This definition leads to several observations. First, SCM takes into consideration every facility that has an impact on cost and plays a role in making the product conform to customer requirements; from not only the inter-functional integration but also outside business partners. Second, the objective of SCM is to be efficient and cost-effective across the entire system. Finally, for SCM revolves around efficient integration of suppliers, manufacturers, warehouses, business customers and individual consumers, it encompasses the companies' business processes at many levels, from the strategic level through the tactical to the operational level. For these business processes, as different parts of the supply channels are in charge of different process, lack of integration leads to inefficient operations. The management of Supply Chains is not an easy task because a large amount of activities must be coordinated across organizational and global boundaries. A typical Supply Chain would include raw materials suppliers, logistics firms, component manufacturers, distributors, and outsourced service firms (Reddy and Reddy. 2001). The most common problems involve coordinating the materials inventory and production capacity availability across several organizations to produce products that can satisfy forecasted demand in an environment with a high level of uncertainty (Strader *et al*, 1999)

Also, Bovet and Sheffi (1998) define Supply Chain management (SCM) as the delivery of enhanced customer and economic value through synchronized management of the flow of physical goods and associated information from sourcing to consumption. It envelops traditionally distinct functions such as forecasting and planning, purchasing, distribution and customer management. Firms retained upstream and downstream activities that are critical to ensuring a smooth flow of products to their customer, their focus shift to manufacturing their core products efficiently to gain cost advantages. La Londe (1998) defines SCM as: "the delivery of enhanced customer and economic value through synchronised management of the flow of physical goods and associated information from sourcing through consumption." Johnston (1995) consider SCM is 'the process of strategically

managing the movement and storage of materials, parts and finished inventory from suppliers, through the "firm and to customers. Rich and Hines (1997) suggest that SCM embraces a strong sense of integration of all activities controlling the timing and synchronisation of material flows.

Supply Chain management (SCM) has often been associated with the management of the physical distribution of products from raw material through manufacturing processes to 'point of sale' for the end product. Chan and Greenwood (2006) summarise that Supply chain management (SCM) has grown as a discipline since the field attracted attention in the 1980's. Also SCM has developed from purely physical management of materials and logistics to understanding demand chains to more recent notions of value chains; the effective SCM can enhance organisational performance and competitiveness through the management of operations across organisational boundaries.

In a discussion of SCM, lean production has to be mentioned as it is an important concept in forming Supply Chain management. The term "lean production" was first presented in the book "The Machine that Changed the World" by Womack *et al.* (1990). In this book, Lean Production is considered as a reaction by the Japanese to mass production. One of the most important lessons from the lean approach is that it attempts customization of high volume production, to provide customers with exactly what they want at the time they want it. Creating a lean approach system is a significant factor to reduce inventory in reducing total production cost and increasing inventory turnover. Therefore, the lean approach is characterized by improving flexibility, reducing waste and improving flow along the Supply Chain. The flow is improved through management and control of each actor along the Supply Chain. This relies largely upon some form of total integration from the raw material supplier to the various subcontractors who supply materials or components to the manufacturer.

Lean construction is a term used for when adopting lean production into the construction industry. It relies on five principles of the Lean Thinking philosophy which are value, value stream, flow, pull and perfection (Womack and Jones 1996). As a result of the implementation of this philosophy, the following can be implemented in construction: systematic waste reduction, operational costs reduction and attainment of commitment and teamwork qualification (Contador 1998). The central themes of lean construction have been eliminating waste and improving workflow in construction (London and Kenley 2001). The lean construction paradigm has produced new kinds of inter-firm relationships.

Supply Chains exist in almost every industry, particularly those that involve product manufacturing. Harland (1996) classifies the applications of SCM into four categories:

- Internal Supply Chains
- Dyadic relationships with immediate suppliers
- The management of a chain of businesses with which you have no direct contractual relationship
- The management of a network of interconnected businesses involved in the ultimate provision of a product to end customers.

The application of SCM techniques is a means of developing vertical integration in the production process - that is to link the process into a chain focussing on maximising the opportunities to add value while minimising total cost. These techniques require a significant shift in the participants toward collaboration, teamwork and mutual benefits. Basically, SCM has two roles:

- directing operations to link successive operating stages through product flow; and
- transforming these operating stages into a single cohesive unit by co-ordinating and controlling internal actions within these stages (Tucker *et al* 2001).

Reddy, R and Reddy, S (2001) suggest that Supply Chain management (SCM) covers

the process and technology of coordinating the smooth flow of products and services among the trading partners and across the Supply Chain. Supply Chain management is aimed at maximum utilization of every trading partners' resources. SCM is traditionally comprised of three areas. They are:

- *Supply Chain planning, (SCP)* Supply Chain planning takes the demand forecast for a product and breaks it down into how the product is going to be manufactured and sourced. It can be thought of as a decision support tool that allows what-if planning based on the constraints within the firm and across Supply Chain. Trading partners participate in planning and setting up the sourcing, manufacturing, and distribution structures to produce the forecasted demand. Supply Chain planning also involves the scheduling of resources within a firm to manufacture or assemble the finished or intermediary products in a cost-effective and efficient manner. Traditional SCP functions include demand planning, planning for direct raw materials procurement and distribution, and scheduling transportation and manufacturing for optimal efficiency.
- *Supply Chain execution (SCE) systems* Supply Chain execution systems focus on reducing unplanned shipping costs and inventory holding costs. For example, Just-In-Time systems reduce working capital and inventory holding costs by procuring raw materials and components just before they are needed for production.
- *Supply Chain transaction (SCT) systems* Supply Chain transaction systems record and integrate all information flows between the trading partners through SCM, SCE systems, or transaction systems. Transaction systems have their roots in the second evolution, the era of production efficiency.

To illustrate differences between Supply Chain and no-Supply Chain transactions, Khalfan *et al* (2001) adopt Sako's comparison of two contractual relationships, which are the arms length contractual, relationship (ACR) and the obligation contractual relationship (OCR) (Sako, 1992).

SCM (OCR)	Non-SCM (ACR)
Pro active	Reactive
Co-operative	Competitive
Trust	No trust
Two-way information	One-way information
Mutual obligation	Contractual obligation
Honour bound to repay	'Take advantage'
Long-term focus	Short-term focus
Interdependence	Independence
Co-destiny	Survival

*Table 3.3 Comparisons of two contractual relationships*

(Adopted from Sako, 1992)

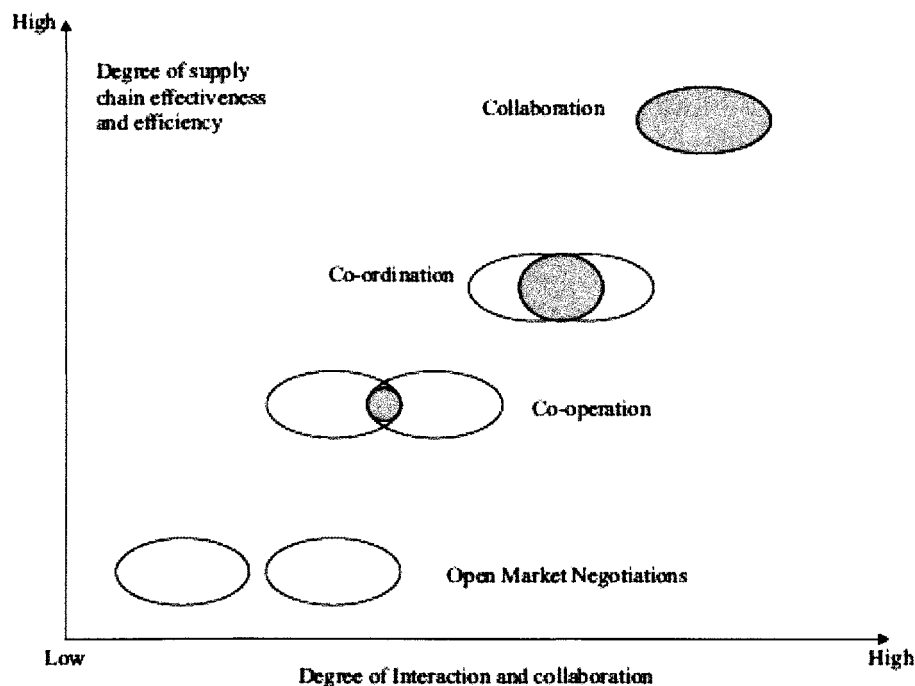
This comparison demonstrates clearly why Supply Chain partners integrate tightly than non Supply Chain transaction partners.

From similar view point, Stevens (1989) provides a model with four stages to describe the transition of a firm from stand-alone to Supply Chain partner.

- Baseline organization. Featured with classical management, motivation by profit maximisation, functional specialisation, slow to adapt to market and slow to exploit innovative opportunities.
- Functionally integrated company. This form starts to focus on customer services, competitive advantages achieved through some internal integration of disparate functions.
- internally integrated company with systems approach to customer service; optimal information flow between departments; medium planning; cross functional management and product focused structure.
- Externally integrated company. In this stage organization has transparent system of materials and information exchange internally and externally; long-term planning and long-term relationships with partners. Organization adopts internal cross functional management structures relating product, and supplier networking groups are implemented.

Considering the industrial features, most construction companies find it hard to reach stage four for a full collaboration within and between organizations. Also for the proposal of supply chain or non supply chain difference, it could be argued that the distinction resides in the fact that the participants are integrated or not rather than whether they are in supply chain or not. Organizations in a string of transactions would have been—by definition—in supply chain, regardless how they behave.

Regarding Supply Chain effectiveness and efficiency and the degree of collaboration among the Supply Chain participants in construction industry, Khalfan *et al* (2004) have proposed a model to illustrate the relationship. This suggests that, as a relationship deepens, moving from open-market, through co-ordination, through co-operation and ultimately to collaboration, then Supply Chain effectiveness and efficiency increases.



*Figure 3.6 Move from traditional open market negotiation to collaboration*

(Adopted from Khalfan *et al*, 2004)

In manufacturing industry, Fazel Zarandi *et al* (2002) studied three major aspects of SC systems which could have some relevance to construction. The three major aspects are “Material Flow”, “Information Flow”, and “Buyer-Seller Relations”

- **Material Flow.** In order to meet customer needs, manufacturers should manage their supply resources to deliver material smoothly. A successful material flow critically needs supportive logistics along Supply Chain from all participants. Transportation planning, inventory management, quality assurance activities and Customer-Driven Manufacturing (CDM).are some important issues in the smoothing flow of materials through the SC. Synchronizing all suppliers in the Supply Chain is somehow complicated and challenging.
- **Information Flow.** There is high level of data transaction as well as material flow along Supply Chain. In an SC system, information management is an essential sector, a well organized information system is a foundation for a proper material flow in the SC.
- **Buyer–Seller Relations** The buyer-seller relation is the main aspect of an SC. Different from traditional approaches focusing on price and cost in establishing buyer-seller relationships, the SC takes more considerations such as quality, R&D, cost reduction, customer satisfaction, and partnerships. Thus, SC adopts a more holistic and comprehensive approach which views both external and internal resources are important. Long term and stable relationships could create more value between organizations along Supply Chain.

The above statement shares similarities with Lee’s (1998) study, which argues that Supply Chain integration and collaboration can deliver not only cost advantages, but also critical competitive advantages in the market place. The integration of SCM lies in three dimensions: information, coordination, and organizational linkage (see Table 3.4 below)

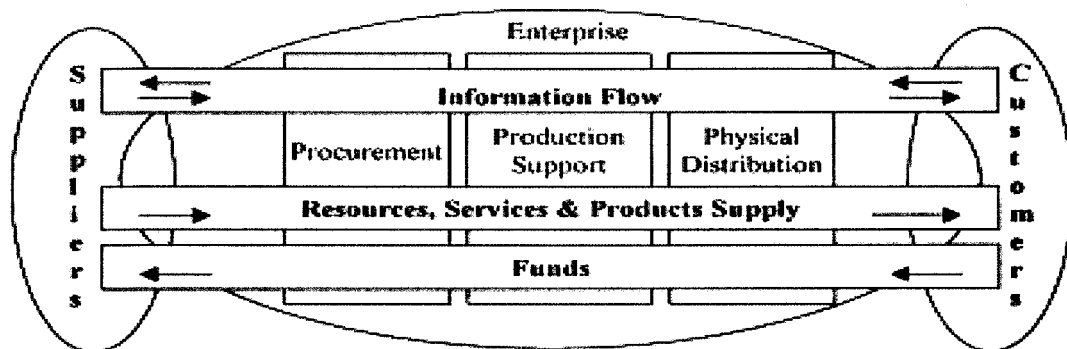


Level of integration	Definition
Information	Sharing of information about critical Supply Chain parameters among Supply Chain partners, e.g. information about production and shipment schedules, inventory levels, promotion plans, sales forecasts, etc.
Coordination	Firms in the Supply Chain allocate decision rights to their partners based on the most effective business process design, e.g. Vendor-Managed Continuous Replenishment Programme where a manufacturer authorizes a supplier to take action based on inventory information
Organizational linkages	Each organization is fully integrated into the business model of its Supply Chain partner(s) with the primary focus on business tasks – organizational boundaries should not present limitations to achieving efficiency and effectiveness of the various tasks. Partners would share not just information or decision rights, but business goals, performance measures, accountability, etc.

*Table 3.4 Integration of Supply Chain*

(Adopted from Lee, 1998)

Also Muya *et al* (1999) suggest three types of construction Supply Chain: the primary Supply Chain, which delivers the materials that are incorporated into the final construction product; the support chain, which provides equipment, expertise and materials that facilitate construction, and the human resource Supply Chain which involves the supply of labour



*Figure 3.7 The Supply Chain concept*

(Adopted from Muya *et al* ,1999)

Though the three levels of chains covers main transactions in Supply Chain, the elements divided into three levels are hard to be distinguished in reality, for instance, it is difficult to identify expertise in support chain or human resource chain in analyzing cases.

Furthermore, a complex theoretical model is developed by Love *et al* (2004)

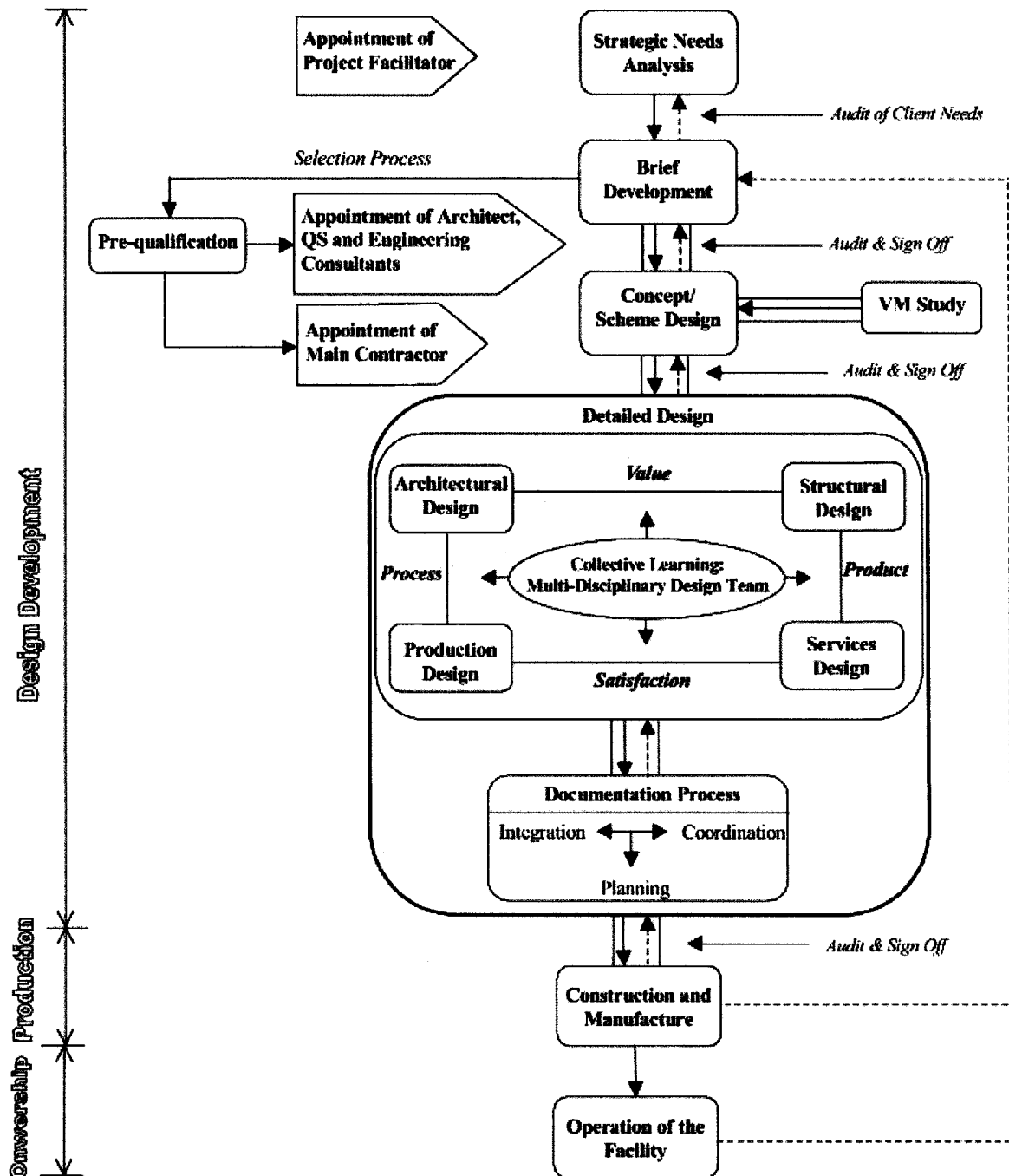


Figure 3.8 Supply Chain model in construction industry

(Adopted from Love *et al*, 2004)

In essence, this model is not different from popular procurement systems being used within the industry. The main difference lays in the emphasis that is placed on inter-organizational collaboration, cooperation and learning. The project team entity in this model positively moves away from the traditional fragmented project team.

Though it takes into account all elements involved in the construction process, it fails to highlight the most important issues that influence project processes.

The differences in the implementation of Supply Chain management lead to different business models. In discussing Supply Chain in construction industry, Tucker *et al* (2001) regard Supply Chain as a dynamic network of interdependent organisations which can be quickly reconfigured to satisfy specific needs of a given customer.

Network organisations are faster to respond than hierarchies as they are characterised by players engaged in reciprocal, preferential and mutually supportive actions use.

Thus, the term Supply Network is to define the process that involves complex links among inter-connected supply entities. (Tucker *et al* 2001). Following the two UK Government sponsored reports (Egan, 1997 and Latham, 1994) in the construction industry, reform in UK procurement methods has been taking place. Supply Chain management (SCM) has been realizing its potential in addressing barriers to efficiency.

In order to overcome fragmentation in the construction industry, a number of integration approaches and strategies adopted after Latham' and Egan's report (1994,1997), included design-and-construct, design-for-construction, Concurrent Engineering, lean construction and business process re-engineering, all of them have been successfully implemented in manufacturing and other industries. But Tucker *et al* (2001) note that these approaches have proved inadequate to cope with the increasing complexity of construction projects. Most of these approaches have tried to focus on elements linked to time, quality and/or cost, and research has noted that 85% of commonly associated problems are process related, and not product related (Tucker *et al* 2001). The traditionally used competitive tendering to procure projects assures that sub-contracting is provided by the lowest-price supplier with little or no guarantee or even incentive to future work, commonly customer-supplier relationships in construction are of the arms-length type rather than being partnerships in this situation.

Construction researchers have applied the SCM philosophy to materials flow, seeking to establish the relationship between site productivity and improved materials management (Akintoye, 1995; O'Brien, 1995; Agapiou *et al.*, 1998; Tommelein and En Yi Li, 1999). In mapping Supply Chain structure, Lambert *et al.* (1998) claim there are three primary structural aspects of an organization's Supply Chain structure: (1) members of the Supply Chain; (2) structural dimensions; and (3) types of process link. With regard to structural dimensions there are three critical dimensions. (a) Horizontal structure refers to the number of tiers across the Supply Chain, which in effect is the number of different functions that occur along the Supply Chain, and indicates the degree of specialization. (b) Vertical structure refers to the number of suppliers and customers represented within each tier. This reflects the degree of competition amongst suppliers. (c) Horizontal position is the relative position of the focal company within the end points of the Supply Chain.

Because SC theory is relation based in its nature, all of the definitions about Supply Chain and Supply Chain management emphasize "integration and collaboration" in the business process. Benefits of collaborative, rather than adversarial, working relationships within construction organisations are well documented (Hampson *et al.*, 2000, Peters *et al.*, 2000; Walker *et al.*, 2000). Collaborative teamwork means sharing information and ideas about on-going work within a team engaged with given activities (Horvath and Varga, 1997). In the context of construction, the key Supply Chain partners are taken as the client, consultants, principal contractor, subcontractors and suppliers. The fundamental benefit of SCM is co-operation and collaboration among different stakeholders. The sharing of information moves the Supply Chain close to the desired goal. Therefore, stakeholders must collaborate to synchronise the output of the entire Supply Chain to fulfil a particular job (Chao *et al.*, 2000). Edum-Fotwe *et al.* (1999) identify the following stakeholders involved in the construction supply-chain

Conceptual	Construction	Maintenance	Replacement	De-commission
Client	Main contractor	Client	Client	Demolition contractor
Project manager	Domestic subcontractors	In-house management	Project manager	
Safety/quality consultant	Nominated subcontractors	Maintenance contractors	Safety/quality consultant	
Architectural designers	Project manager	Facilities consultant	Architectural designers	
Civil designers	Material suppliers	Insurance agency	Civil designers	
Structural designer	Plant/equipment suppliers		Structural designer	
Mechanical designer	Designers		Mechanical designer	
Electrical designers	Financial institution		Electrical designer	
Specialist designers	Insurance agency		Specialist designers	
Cost consultant	Regulatory bodies		Cost consultant	
Financial institution			Regulatory bodies	
Insurance agency			Main contractor	
Regulatory bodies			Domestic subcontractors	
			Nominated subcontractors	
			Material suppliers	
			Plant/equipment suppliers	

*Table 3.5 Stakeholders involved in the construction supply-chain*

(Adopted from Edum-Fotwe *et al.*, 1999)

These suggestions can be traced back to Egan's report (1997), in which some key elements were suggested in the adoption of SCM in the construction industry:

- Acquisition of new supplier through value based sourcing.
- Organization and management of the Supply Chain to maximize innovation, learning and efficiency
- Supplier development and measurement of suppliers' performance
- Managing workload to match capacity and to incentivise suppliers to improve performance
- Capturing suppliers' innovation in components and systems

SCM has its own unique features in construction industry mainly because that construction project teams are unique entities, created through a complex integration of factors, with inter-disciplinary players, varying roles, responsibilities, goals, and objectives (Goodman and Chinowsky, 1996). Vollman *et al.* (1997) believe that construction SCM is increasingly seen as a set of practices aimed at managing and co-ordinating the entire chain from raw material suppliers to end customers. From this point, construction SCM may be regarded as the process of strategic management of

information flow, activities, tasks and processes, involving various networks of organisations and linkages (upstream and downstream) involved in the delivery of quality construction products and services through the firms, and to the customer, in an efficient manner.

Wong and Kanji (1998) suggest that construction SCM, can successfully address major problems of the industry and its clients if SCM is associated with partnering and total quality management in construction industry. In linking SCM with TQM, Wong and Fung (1999) conclude that SCM must be a vital part of the total quality objectives of a general contractor. They recommended that in managing the Supply Chain for total quality, the general contractor must develop an enabling structure and an efficient communication system for effective relationship management as part of project management.

Akintoye *et al* (2000) identify the principal objectives in developing construction Supply Chain collaboration in construction industry as the following:

- Benefits to the client
- Improved customer service
- Reducing bureaucracy/ paperwork
- Increased profitability
- Cost reductions within organisation
- Increased market competitiveness
- Benefits to the supplier
- Improved quality assurance
- Overall Supply Chain reduction

Therefore, Akintoye *et al* (2000) propose key factors in effective construction Supply Chain relationships as:

- Trust
- Reliability of supply

- Top management support
- Mutual interest
- Free flow of information
- Joint business planning
- Closer links between demand/ supply
- Integrated information systems
- Manpower development
- More frequent meetings

And major barriers to construction Supply Chain relationships as:

- Lack of top management commitment
- Poor understanding of the concept
- Inappropriate organisation structure to support system
- Low commitment of partners
- Strategic benefits unclear
- Lack of appropriate information technology (Akintoye *et al* 2000)

In order to present collaboration activities in large scale, Lamming (1999) introduced the term “Supply Network” to define the process that involves complex links among inter-connected supply entities. The theory of “Supply Network” view supply channels as a dynamic network of interdependent organisations that can be quickly reconfigured to satisfy specific needs of a given customer. Powell (1990) argues that network organisations are faster to respond than hierarchies as they are characterised by players engaged in reciprocal, preferential and mutually supportive actions. The advantages of building such networks with suppliers have been particularly emphasised (Carlisle and Parker 1989). These networks depend upon achieving mutually beneficial relationships, which embrace dimensions of trust, relationship stability, relationship longevity and shared inter-organisational purpose (D’Cruz and Rugman, 1994). The organisations in the network are supposed to be fully integrated



in, with business opportunities developed in reaction to clients' needs (Fernie *et al.*, 2000).

From the discussion above, it is clear that collaboration and teamwork along Supply Chains are crucial in the construction industry; cooperation between participants leads to minimising errors, reduction of time delays and finally results in cost reduction and performance improvement. In fact, all of the previously discussed managerial concepts, from transaction costs, quasi-firm/and temporary organization, Concurrent Engineering and Supply Chain/network management in construction, emphasize similar points in reducing costs and improve performance. These points are, trust, effective and efficient communication, collaborative working such as partnering. Indeed Supply Chain Management cannot take distinguish itself from patterning activities in construction industry, at least many firms must collaborate intensively throughout a project life cycle no matter if they will collaborate in other future projects. The following section discusses collaborative working and partnering in more detail.

### **3.3 Partnering to meet challenges**

The previous sections have discussed some of the management methods recently applied in the construction industry. The relationship between organizations operating in construction projects is a key issue in understanding the different management methods. Though the general trend in construction practice is turning to collaborative working relations, relationships are still dominated by contracts. The widely used contracts increase transaction costs fail to improve effectiveness and efficiency, by reinforcing poor quality of working relationships between project parties.

Particular attention has focused upon improving the quality of relations between

project participants and encouraging mutual adjustment between design and construction processes. Regarding the quality of relations, trust and proximity with other organizations are being considered as key organizational issues and lead to attempt to collaborative working. Trust is expressed through faith, reliance, belief, or confidence in the supply partner. A company can co-operate and be co-ordinated in a Supply Chain but not collaborate (Khalfan *et al* 2001). Collaboration requires high levels of trust, commitment, and information sharing among Supply Chain partners (Sinclair, 2000). In addition, partners also share a common vision of the future (Spekman *et al.*, 1998). In the construction industry, there has been a growing recognition that it is important to integrate all the members of the Supply Chain from the various disciplines with trust in order to adopt collaborative working philosophy and partnering arrangement under the challenges of reform.

Chadwick and Rajagopal (1995) identify four key differences between the traditional adversarial approach to procurement and the more recent trend towards partnering, namely: (1) an emphasis on cost rather than price, (2) a long-term rather than a short-term focus, (3) defect prevention in place of quality checks, and (4) single, rather than multiple, sourcing. In a study of success factors and the benefits of partnering in construction, Black *et al.*(2000) conclude that partnering is increasingly being used in construction projects. Partnering in Black *et al.*(2000) research is regarded as the parties involved to a construction project working together, in an environment of trust and openness that realises efficiency without conflict and working..

According to Luck (1996, p.1), “partnering and integration strategies attempt to address a fundamental characteristic of the industry . . . that it is fragmented, as individuals from different organizations which are geographically and temporally dispersed are involved in the construction process’ .

The following section starts by presenting definitions of partnering followed by

analysis of partnering practice in construction industry. Finally, trust, support and commitment are discussed as fundamental factor and key issues due to their importance in practice and for this research.

### **3.3.1 Partnering, concepts and key issues**

According to Egan (1998) “partnering involves two or more organisations working together to improve performance through agreeing mutual objectives, devising a way of revolving any disputes and committing themselves to continuous improvements, measuring progress and sharing gains”(p.8)

Lorrain (1994) suggests that modern partnering developed from the Japanese motor manufacturing industry of the 1960s, later adopted by American construction industry. In a partnering arrangement, the most important element at the beginning is long-term relationships between manufacturers and key suppliers. As discussed in previous sections, lack of trust and competing on price rather costs had become main problems in the UK construction industry. Partnering has been adopted as a tool for improving the performance of the construction process and emphasizes the way it helps to create synergy and maximize the effectiveness of each participant’s resources (Barlow *et al.* 1997). Bubshait (2001) describes partnering as an innovative and effective project organisation concept and suggests the key benefits are from success of partnering are cost reduction and conflict minimisation in the construction industry.

The overall philosophy of partnering has been discussed from behaviour, attitudes, values, practices, tools and techniques. Crowley and Karim (1995) consider that partnering can be defined in the following ways:

- by its attributes such as trust, shared vision, and long-term commitment; and
- by its process, whereby partnering is seen as a verb and includes developing

mission statements, agreeing goals and conducting partnering workshops.

According to the Construction Industry Institute in the USA (CII 1991, p. iv), partnering is “a long-term commitment between two or more organizations for the purposes of achieving specific business objectives by maximizing the effectiveness of each participant resources. This requires changing traditional relationships to a shared culture without regard to organizational boundaries. The relationship is based on trust, dedication to common goals, and an understanding of each other’s individual expectations and values. The expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and services.” Similarly, partnering has been defined as ‘a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant’s resources’ (NEDO, 1991, p. 5).

Furthermore, Cox and Townsend’s (1998) define partnering thinking of construction industry as:

“Partnering is a long term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of each participant's resources... The relationship is based on trust, dedication to common goals and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and service.”

From literature it emerges that partnering could be classified into two types which are single project partnering and long-term partnering (strategic partnering) according to the duration of the business transaction.

Project partnering is a collaborative relationship between organizations for the

duration of a specific project (Barlow *et al.* 1997). At the end of the project, the relationship is terminated and another partnering may commence on the next project (Kumaraswamy and Matthews 2000).

Strategic partnering is a relationship with a high level of cooperation between partners (Barlow *et al.* 1997), which takes place when two or more firms use partnering on a long-term basis to undertake more than one construction project, or some continuing activity (Kumaraswamy and Matthews 2000).

Third generation partnering or “industrial level” partnering is proposed by Kubal (1994) and The Reading Construction Forum (RCF, 1998), who suggest that this type of partnering would come about when the construction industry becomes collaborative, producing and marketing a range of services in which clients wanted to invest. It also suggested that long-term collaborative nature of third generation partnering producing cost savings of 50 per cent or more, and time savings of 80 per cent.

In general, the adoption of partnering is intended to reduce the adversarial relationships which are built under price-bidding procurement system, and which were typical of the industry before reform and lead to two government reports for encouraging better integration and cooperation between contractual partners. Both Latham and Egan report emphasize the importance of partnering in reforming the UK construction industry in order to reduce costs and improve overall performance. Latham (1994) firstly uses the term of partnering in his report to refer long term relationship formalization under partnering arrangement. Latham report points out the importance of trust and openness in order to maximise all parties’ resources and expertise under partnering agreement. The agreement is intended to establish contractual relationship over certain period, or further more, indefinite time. It is a transformation from adversarial relationships to collaborative working. In partnering relationship, all transaction parties could resolve problems jointly and informally

through more effective forms of inter-firm collaboration. From his report and the intention of partnering agreement, it is clear that trust is in the heart of partnering and collaborative working at the very beginning, it provides foundation for the entire establishment of partnering.

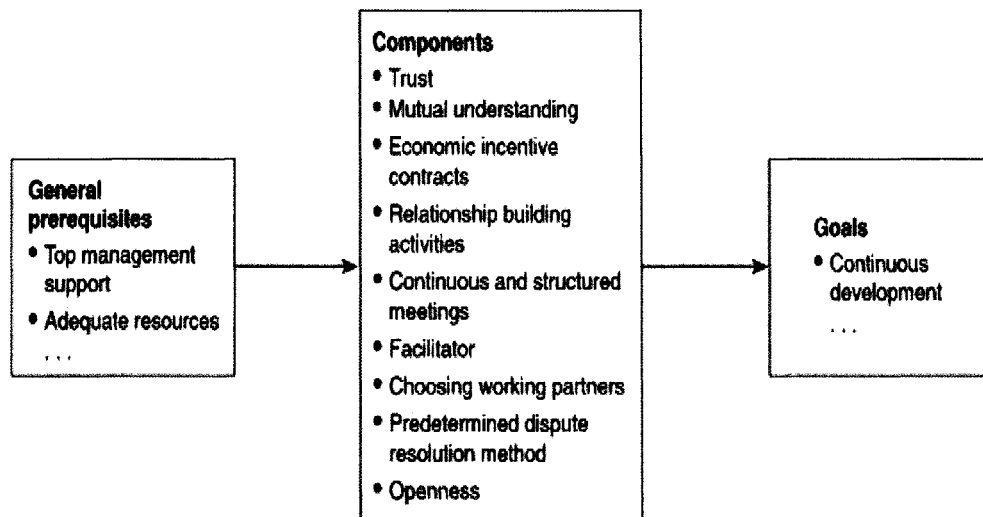
There is broad agreement about partnering working relationships, but there is still no sound agreement about precise definition of “partnering” in construction industry. Normally, the term ‘partnering’ is used to define a range of cooperation in any type of collaborative project (Barlow and Cohen, 1996). Barlow *et al* (1997) consider partnering is a label used for a variety of alternative approaches to managing business working relationships. Holti and Standing (1996, p. 5) suggest that “rather than being a separate or definable initiative in its own right, partnering or increasing collaboration is best understood as the result of making progress with one or more of a number of inter-related technical and organizational change initiatives’. More recent understanding of partnering simplifies the term by viewing the diversity of partnering practices as being ranged along a continuum from competition to cooperation, collaboration and coalescence (Thompson and Sanders, 1998). Essentially partnering seeks to develop closer relationships between parties in a project.

In construction practice, the partnering procurement method aims to eliminate adversarial relationships between client and contractor by encouraging the parties to work together towards shared objectives and achieve a win/win outcome (Watson 1994). But some there is still no sounded definition for this term of “partnering”. Anyway, there are several definitions widely cited in this research field. Matthews' (1996) concludes that the following elements are normally discussed in the partnering literature:

- goals and objectives;
- trust;
- problem resolution;
- commitment;

- continuous evaluation;
- group working and teams;
- equity;
- shared risk;
- win-win philosophy; and
- collaboration/co-operation.

Later Nystrom (2005) argues that it is difficult to give precise definition of partnering. He divides all elements discussed in partnering definitions into three categories with developing relationship which are illustrated below



*Figure 3.9 Distinction of partnering factors*

(Adopted from Nystrom, 2005)

From these factors Nystrom (2005) identifies key elements for successful partnering

Elements of partnering
Goals and Objectives
Trust
Problem Resolution
Commitment
Continuous Evaluation
Group Working / Teams
Equity
Shared Risk
Win-Win Philosophy
Collaboration / Co-operation

*Table 3.6 key elements for successful partnering*

(Adopted from Nystrom, 2005)

Despite his argument about numerous definitions of partnering, he merely identifies issues involved in partnering practice rather than providing a clear definition based on his argument, but these key elements are still useful for analysing partnering relationships.

Barlow *et al.* (1997) regard partnering as a management process that helps the strategic planning to improve the efficiency of the enterprises, and forms a team with common objectives. Also Barlow *et al.* (1997) mention six successful factors of partnering: building trust, teambuilding, the need for top level commitment, the importance of individuals, the strategic movement of key personnel, and the need of open and flexible communications. The benefits from partnering relation are: reduced costs, shortened delivery time, improvement in construction quality, better working atmosphere, and organizational learning (Barlow *et al.* 1997). Similarly, Matthews' (1996) research identifies that the benefits of partnering lay in the following areas:

- contractual situation;
- communication and information flow;
- level of understanding;
- efficiency of resources;
- financial position; and
- quality.



Though the general trend in the UK construction is transforming to collaborative working, some studies have shown problems in implementation. Green and McDermott (1996) point out the use of partnering methods *per se* does not necessarily lead to effective outcomes (or even collaboration), in the same way that using traditional forms of contract does not necessarily result in poor performance, or even conflict. In a recent study, Barratt (2004) concludes some difficulties arise in collaborative working which are:

- Over-reliance on technology for implementation;
- Failure to differentiate between whom to collaborate with; and
- Lack of trust between trading partners.

Dainty *et al* (2001) also find scepticism from sub-contractors in construction relating to collaborative working.

Hughes *et al* (2006) draw a continuum for working relationships which starts from open competition to selective competition, negotiation and collaboration, and ultimately collusion. He raised the question that “is your collaboration really collusion?” Hughes *et al* (2006) argue that the state of market is an important factor in selecting procurement systems.

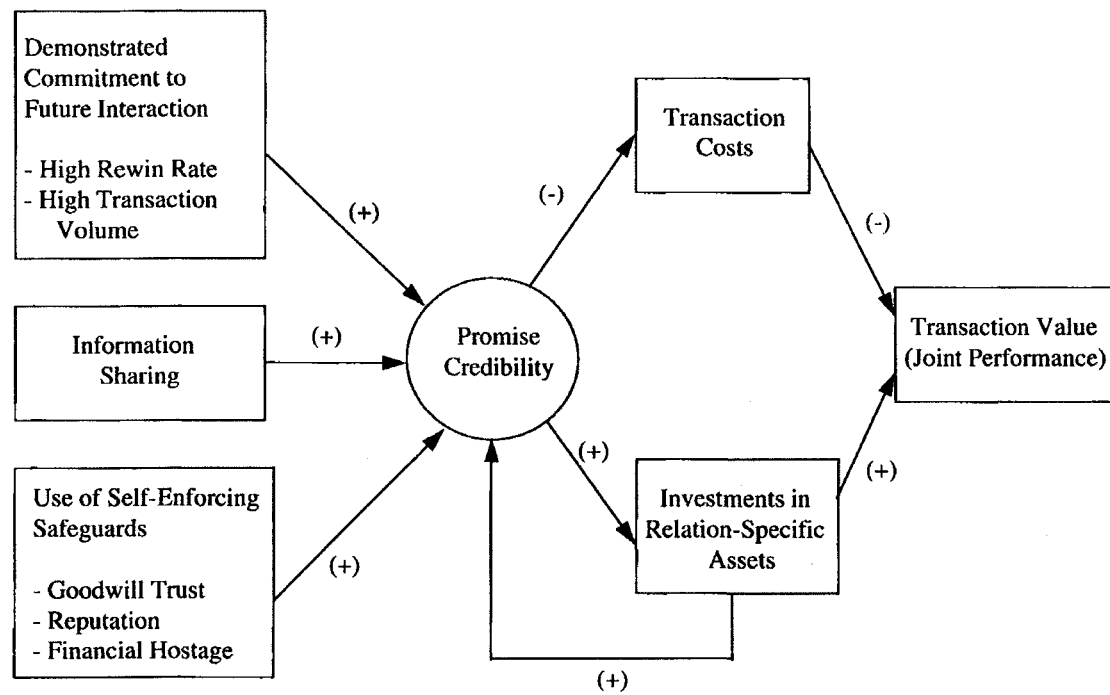
Barratt (2004) considers that the following four questions should be addressed first in order to implement collaborative working successfully.

- Why do we need to collaborate?
- Where and with whom can we collaborate in the Supply Chain?
- Over what activities can we collaborate? and,
- What are the elements of collaboration?

Similarly, Khalfan *et al* (2001, 2002) identify that the key barriers to greater collaboration and integration are the fragmentation of project delivery systems, lack of trust, and adversarial contractual relationships. While Hall (2001) argues that the key to improving the performance of the construction industry requires:

- a move from contractors' selection based on traditional, lowest cost to best value;
- a move to a position where all suppliers have a close relationship with the client (rather than just the "main" contractor); and the avoidance of the dispersal of the project team at the end of each project.

Since collaboration and inter-firm relationship have long been key points of partnering, Dyer (1997) studied inter-firm collaboration from transaction costs view point and proposed a model of inter-firm collaboration that maximizes transaction value.



*Figure 3.10 inter-firm collaboration model to maximize transaction value.*

(Adopted from Dyer, 1997)

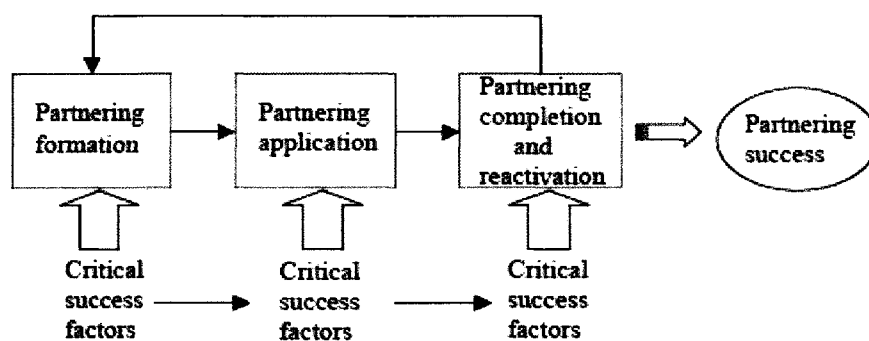
The model suggests that the credibility of a interdependence of the firm's promise to behave collaboratively increases as transactors:

1. demonstrate through behaviour a commitment to future interaction (e.g., by increasing the re-win rate and volume of exchange),

2. increase the amount of information sharing, and
3. employ self-enforcing safeguards to govern the relationship. In turn, an increase in 'promise credibility' (or trustworthiness) within the trading relationship reduces transaction costs and increases the likelihood that transactors will invest in relation-specific assets.

Furthermore, increased investments in specialized assets serve to reinforce the transactors' promise credibility by increasing the cost of unilateral defection and lengthening the 'shadow of the future.' Finally, lower transaction costs and greater investments in specialized assets maximize transaction value, or the joint performance of the transactors. This model covers most issues arise in transactional relationships, but there is not indication of the degree of increase or decrease from influences, and it is far too complex in implementation.

Cheng & Li (2001) developed a conceptual model of construction partnering which explores the relationship between two types of partnering (project and strategic). By studying the key factors that affect the partnering process stages. It helps to determine the critical success factors (CSFs) of the two types of partnering. This model proposes that there should be an individual set of critical factors affecting project or strategic partnering, while some of these CSFs are likely to affect both types of partnering (Cheng & Li 2001).



*Figure 3.11 the critical success factors (CSFs) of partnering*

(Adopted from Cheng & Li, 2001)

According to Cheng & Li (2001), this conceptual model uses a three stage process: formation, application, and completion and reactivation, which forms the basis for considering what factors lead to the success at each stage for the two types of partnering (project and strategic). The stages are explained as

- Partnering formation refers to an agreement, implicitly or explicitly, made by all key construction parties to establish an informal relationship for the purpose of accomplishing mutually agreed goals and objectives.
- Partnering application refers to the execution of the informal relationship to accomplish the mutually agreed goals and objectives in line with the construction project.
- Partnering completion and reactivation (hereinafter called partnering reactivation) refers to the intention of the construction parties to re-run an informal relationship with the same group of companies for a new project after the completion of the current project. If they want to form another partnering cycle, then measuring the partnering performance is crucial as it provides information indicating how to improve in order to achieve a more successful partnering establishment (Cheng & Li 2001)

The research of Cheng & Li shows that top management support, open communication, effective co-ordination and mutual trust as being all critical at all the three process stages of both project and strategic partnering. In addition, partnering agreement and facilitator are critical at partnering formation stage of project partnering, while partnering agreement is critical at the formation stage of strategic partnering. Meanwhile, adequate resources and joint problem solving are critical at the stage of partnering application of both types of partnering. Team building is critical at partnering formation stage of both types of partnering, while it is critical at the application stage of project partnering and the reactivation stage of strategic partnering. Long-term commitment, continuous improvement and learning climate i.e.

are critical in all three stages of strategic partnering (Cheng & Li 2001).

### **3.3.2 Trust, support and commitment**

From the literature reviewed above, including definitions of partnering, the identification of key elements of partnering and other matters concerning partnering in practice, it could be concluded that trust, support and commitment are three key elements in collaborative working which distinguish it from traditional, adversarial working. Other elements, such as “mutual aims” “efficient communication”, could be traced in competitive working environment as well as collaborative working circumstances. For clarification, “support” and “commitment” used here means the support and commitment beyond the obligations in contract or agreement. These three elements are proposed as key elements or critical success factors. In Egan’s two reports (1998, 2002), trust is identified as a key element of building in the integrated project team which is proposed as a cure for fragmentation in this industry. In business practice, trust is said not only to reduce transactions costs, make possible the sharing of sensitive information, permit joint ventures of various kinds, but also to provide a basis for expanded moral relations in business (Brenkert 1998).

McDermott *et al* (2005) have observed that where the concept of Supply Chain integration and collaboration is gaining increased acceptance in construction industry, the project participants are realising that the sharing of knowledge and information is one of the key elements of success. Based on this observation, their study argues that even where there are efficient Supply Chain processes in place, high levels of collaboration require trust. Trust makes information flow smooth, and creates a knowledge sharing environment in which the whole Supply Chain progresses and develops. Trust is used to manage information flows, which is seen as a more effective approach than the use of contracts (McDermott *et al* 2005).

This research considers that trust is a foundation for the later two elements, support and commitment. Support and commitment are reflections of trust in practice level and trust remains in psychology or philosophy level, which lead to support and commitment in certain situations. Taking the McDermott's study as example, this research is to identify trust as a basic point and working philosophy, the reflections in practice are sharing information seamlessly and creating knowledge sharing environment, which are commitment, support or supportive activities could be detailed as "open book exchange", "creative solution identification", "informal meeting" etc.

From a business management viewpoint, Rosseau *et al.* (1998, p. 395) define trust as a "psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another". Wood and McDermott (1999) suggest that trust is "a willingness to rely on the actions of others, to be dependent upon them, and thus be vulnerable to their actions. We are mainly interested in trust as it affects the willingness to co-operate". McDermott *et al* (2005) conclude that trust is an exchange-based concept that is centred on risk, with elements of reliance, goodwill vulnerability and with an expectation of outcomes

Lyons and Mehta (1997) identify two types of trust

- self-interested trust, which essentially is future orientated in terms of the expectation that one's transaction partner is trustworthy and will not behave opportunistically in future transactions; and
- socially orientated trust, which is past orientated in that it is generated through obligations generated through social and family networks.

Furthermore, Kadefors (2004) suggest the following three basic forms of trust:

- Calculus-based trust describes a rational choice perspective, where trust emerges when the trustor (the trusting party) perceives that that the trustee (the trusted party) intends to perform an action that is beneficial to the trustor. In this

perspective, individuals are regarded as motivated primarily by economic self-interest, and calculus based trust is often based on the existence of economic incentives for co-operation or contractual sanctions for breach of trust.

References, certificates and diplomas and other tangible information that communicate what performance and competence to expect from a potential exchange partner may also influence calculus based trust.

- Relational trust arises between individuals who repeatedly interact over time. Through this relationship, the involved parties obtain direct, personal experience and information that forms the basis of trust, and emotions and personal attachments influence the relationship. Indeed, the frequent use of concepts such as ‘vulnerability’ and ‘betrayal’ in relation to trust indicates that strong feelings are involved and that there are psychological and social risks apart from the financial ones.
- Institution-based trust refers to the role of institutions in shaping the conditions necessary for trust to arise. Important institutions in this regard are legal systems and societal norms pertaining to conflict management and co-operation, as well as systems regulating education and professional practice. Institutions in the form of cultural rules influence our preconceptions of the trustworthiness of various categories of people and organisations.

The study by McDermott *et al* pays attention to trust in the work of other researcher (Khalfan *et al* 2002, 2001; Wilson and Kennedy 1999; Cummings and Bromiley 1997; Masden 1991; Williamson, 1985; Ouchi 1980 ) and in terms of economics, especially from a transaction cost approach. These researcher have argued that trust can reduce transaction costs by reduction of control and monitoring mechanisms (Masden 1991), trust allows firms in market-transaction operating like hierarchy-transactions (Ouchi, 1980). Ouchi 's (1980) research confirms that the costs of market exchange/transactions are lowered when levels of trust are higher. Benheim and Birchall (1999) point out that partnering and collaborative approaches can reduce fragmentation and then reduced transactions costs should be achieved by building

trusting relationships in project parties.

Thus, McDermott *et al* (2005) assert that trust is the foremost element of the collaborative working concept. The procurement approach – if it does not allow the processes of trust to take place, or makes trusting behaviour difficult – is potentially the greatest barrier to collaboration.

## Summary

This chapter reviewed the British construction industry's responses to its critics. This included the adoption of management concepts which include transaction cost theory, quasi-firm and temporary organization theory, and methods and tools including Concurrent Engineering, Supply Chain management and finally partnering and collaborative working.

All the foregoing is concerned with the relationship between participants. Trust and support, proximity, shared aims; efficient communication and mutual commitment are highly valued for the successful implementation of all these management methods. Partnering and collaborative working finally emerge as a method to integrate all of these key elements above. The base of partnering is a high level of inter-organisational trust and the presence of mutually beneficial goals. The advocates of partnering and collaborative working consider that trust, support and commitment can bring mutual benefits to all participants. These benefits include improved risk control, cost reduction, more efficient working, better performance and satisfied participants as well as the client. In Egan's two reports (1998, 2002), trust is identified a key element of building the integrated project team which is a cure for fragmentation in construction industry.



To date, partnering is understood as a set of collaborative processes, which emphasizes the importance of common goals. The base of partnering is a high level of inter-organisational trust and the presence of mutually beneficial goals. Therefore, it is for this reason that a relationship network perspective is proposed to research to construction from a relationship network perspective which would provide meaningful explanation about project process. From Knowledge Management viewpoint, all of these partnering and collaborative workings are about knowledge integration across organizational boundaries as the most important is the professional knowledge rather than physical commodities.

# Chapter 4 Network perspective in social context

## 4.1 Organizational networks

The management approaches reviewed in the last chapter face limitations by isolating organizations from their tightly connected context. Though they all appreciate the importance of relationships, those theoretical frameworks still focus on the economic dimension in analyzing business activities. Tichy *et al.* (1979) advocates the network perspective in the study of organizational behavior and emphasizes the social dimension. Therefore, this chapter's purpose is to introduce social network perspectives in addressing project.

Due to the division of labour and accompanying fragmentation, specialization and distribution of knowledge, it becomes a requisite to integrate and thus share the diversity of complementary knowledge in order to produce complex products and services. An organizational setting has just been implemented or has emerged since none of the actors involved could produce the collective outcome individually (Boer *et al.*, 2002). Reich (1991: p81) regards a firm as a facade, behind which an array of decentralized groups and subgroups exist continuously contracting with similar diffuse working units all over the world.

According to Seufert *et al.* (1999), the term 'network' designates a social relationship between actors. Actors in a social network can be persons, groups, but also collectives of organizations, communities or even societies. The relationships evolving between actors can be categorized according to contents (e.g., products or services, information, emotions), form (e.g., duration and closeness of the relationship) and

intensity (e.g., communication-frequency). Since the boundaries of networks are difficult to determine, blurred boundaries are constructed socially by the network members. Based on organizational theory, Grandori and Soda (1995) consider networks as nexuses of integration mechanisms encompassing all the range of organizational inter-firms coordination and cooperation. Network perspectives build on the general notion that economic actions are influenced by the social context in which they are embedded and that actions can be influenced by the position of actors in social networks (Gulati, 1998). By taking this perspective, managerial concerns shift from the consideration and protection of the boundaries of a firm to the management of and care for relationships (Seufert *et al* 1999).

Seufert (1999) also points out that market relationships are short-term and competitive, while hierarchies coordinate activities on the basis of instructions given to a limited number of organization members. Ideally, these instructions replace the need for every market-based coordination. Coordination occurs by contract and comprises discrete transactions as well as blurred interactions (like for example helping people to speed up their career). In contrast to market relationships, hierarchical ones are ideally long-term and co-operative.

In fact, all organizations have to cooperate in some way in order to combine their resources (Eccles, 1981). A large number of co-operating partners increases the direct links between the main actors in a network which normally put demands on higher degree of formalization, e.g. more formal type of organization, flow of information, and decision making (Bohman and Lindfors 1998).

There are five basic reasons for taking a network perspective on organizations (Nohria and Eccles, 1992, p. 4):

- All organizations are social networks and therefore need to be addressed and analysed in terms of a set of nodes linked by social relationships;

- The environment in which an organization operates might be viewed as a network of other organizations;
- Organizations are suspended in multiple, complex, overlapping webs of relationships and we are unlikely to see the overall pattern from the point of view of one organization;
- Actions (attitudes and behaviour) of actors in organizations can best be explained in terms of their position within networks of relationships;
- The comparative analysis of organizations must take into account their network characteristics.

Powell (1990) considers that a network is a form of organization in business practice. Network relations are perceived as the most central feature in moving the industry forward in the perspective of the “network form” (Powell, 1990). The functional explanation for the emergence of the “network form” claims that the opportunities for innovation exist within firms as well as in their external networks, and the ability of an organization to learn results from its capacity to utilize both its own internal capabilities and the opportunities within its network through various forms of collaboration. In the context of networking, “network forms” of organization have been described as a source of value for the firm (Kogut, 2000). Network based industries can be expected to generate new forms of collaboration, in which network partnerships will be based on maximizing resource utilization subject to the equitable distribution of returns, rather than on individual firms maximizing their profits (Miles, *et al.*, 1998).

By analyzing business activities with transaction costs theory, Barney and Hesterly (1999) argue that transaction costs theory overlooks the role of social relationships in economic transactions. Some authors (Thorelli, 1986; Siebert, 1991; Sydow 1992) regard networks as a hybrid form of organization since networks have features of market and hierarchy. This form of organization demonstrates stronger incentives and adaptive capabilities than hierarchies, but can offer more administrative control than

markets (Williamson, 1994). Thus, for transactions that require a mix of incentives, adaptation, and control, the hybrid maybe the best form to be selected (Barney and Hesterly 1999). Similarly, Podolny and Page (1998, p. 59) coin the term 'Network Organizations' and explain it as "any collection of actors that pursue repeated, enduring exchange relations with one another and, at the same time, lack a legitimate organizational authority to arbitrate and resolve disputes that may arise during the exchange". This form of organization excludes pure market arrangements such as single transactions or short-term contracts, and is distinct from hierarchies that have a legitimate authority to resolve disputes.

Also from a transaction cost perspective, Dyer's research (1997) demonstrates that inter-firm relationship management could minimize transaction costs from the following aspects:

- *Search costs* include the costs of gathering information to identify and evaluate potential trading partners;
  - *Contracting costs* refer to the costs associated with negotiating and writing an agreement;
  - *Monitoring costs* refer to the costs associated with monitoring the agreement to ensure that each party fulfils the predetermined set of obligations;
  - *Enforcement costs* refer to the costs associated with ex post bargaining and sanctioning a trading partner that does not perform according to the agreement.
- (Dyer 1997)

By comparing automotive industries both in Japan and USA, Dyer(1997) argues that Japanese auto-makers have lower transaction costs than their U.S. counterparts primarily due to:

- repeated transactions with a small set of suppliers;
- economies of scale and scope in transacting with that small supplier group (high volume of exchange between transactors);
- extensive inter-firm information sharing which reduces asymmetric information;

- the use of non-contractual, self-enforcing safe-guards (i.e., goodwill trust) which are effective for an indefinite time horizon (as opposed to contracts which are effective for a finite time horizon);
- investments in co-specialized assets.

This empirical research concludes the advantages of inter-firm cooperation by adapting a network perspective; the inter-firm relationships have been proved an important capital and managerial concerns in practice.

In the empirical study of strategic alliances, Gulati (2000) points out that network facilitate firms in the network in gathering superior information, thus reducing the informational asymmetries which otherwise may cause higher transaction cost.

Networks can further mitigate transaction costs by making opportunism more costly because of reputational effects. Businesses take time to build reputations in society, but this reputation can be damaged overnight. Consequently, it is essential that firms exercise caution in protecting their reputation, and the network can help create a strong disincentive barrier against opportunistic behaviour (Wang *et al.* 2004).

Wang *et al.* (2004) also view inter-firm networks as recourses which enable business to sustain above-average performance because they meet three criteria established by Barney (1999)

- resources being valuable;
- resources being rare;
- resources being imperfectly imitable.

All the points concluded above can be achieved by successfully managing inter-firm relationship. The inter-firm network is regarded as an organisational resource or business asset (Wang *et al.* 2004). Business networking has been being discussed at strategy level and viewed as critical external resources (Gulati *et al.* 2000), networked-firms are considered to have a higher opportunity of survival, compared

with those un-networked (Uzzi, 1996), firms are more reliable and creditable for both customers and suppliers when integrated into a higher level of networks (Malecki and Veldhoen, 1993). Investments in relation-specific assets are often correlated with superior performance (Parkhe, 1993), because inter-firm cooperation enables firms to share resources and thereby overcome resource-based constraints to growth (Hamel, 1991). Networks differ in terms of degree of complexity, concentration of power balance, environmental diversity and stage of network development (Harland *et al.* 2001).

Furthermore, several concepts are proposed by adopting a network perspective. Davidow and Malone (1993) propose that this hybrid form of organization could be defined by “virtual corporation”. Later this concept evolved into a “virtual organization”, which is an organization formed based on “temporary network of independent companies – suppliers, customers and rivals – linked by IT to share skills, costs and access to one another’s market” (Byrne, 1993). Christie and Levary (1998) define a virtual organization as a “temporary network or loose coalition of manufacturing and administrative services that comes together for a specific business purpose.... Virtual organizations are extremely focused, goal driven, and powered by time-based competition.” Moss-Kanter (1994) coins the term “networkability” which is explained as “the propensity to be a good partner”, and “collaborative advantage” which aims at pursuing common goals when applied to a specific relationship. Achieving networkability is at the heart of business networking, which describes the design and management of relationships (internal or external) between business units. By building on their embeddedness in business networks (Granovetter, 1985), organizations can promote economies of time (e.g. the ability to capitalize quickly on market opportunities resulting from network-based knowledge relations) and complex adaptation (Uzzi, 1997). Social networks and social capital are to be discussed later in this chapter.

Lipnack and Stamps (1994) state that network organizations are characterized by five

key organizational principles:

- **Unifying Purpose.** Common views, values, and goals hold a network together. A shared focus on desired results sustains synchronized operations and network directionality;
- **Independent Members.** Each member of the network, whether an individual, company, or country, can continue to sustain its independent existence while benefiting from being part of the whole;
- **Voluntary Links.** The distinguishing feature of networks is their links, partners join forces voluntary;
- **Multiple Leaders.** Fewer bosses, more leaders. Each person or group in a network has something unique to contribute at some point of the process. With more than one leader, the network as a whole has greater resilience;
- **Integrated Levels.** Networks are multilevel, not flat. Networks operate on different levels, i.e. co-operation between organizations, departments and people.

Though the five principles are useful for identifying networked organizations, they fail to explain how to create a successful networked organization, as most of the features concluded above are developed without formal organizational management intervention.

Regarding organizations in projects, Jones (1999) considers that the project organization is best thought of as a project network, because projects are normally produced through a dynamic network of transactions involving specialized firms, subcontractors and freelancers

In business practice, inter-firm relationship development has been studied from business strategy level based on organizational resources approach. The network perspective contributes to explaining patterns of business strategy, in highlighting that the social role and embedded social context facilitate or inhibit business activities (Gulati 2000). Gulati (2000) suggests that a firm's network can be thought of as



creating inimitable and non-substitutable value as an inimitable resource by itself, and as a means to access inimitable resources and capabilities” (p.207).

At organizational strategic level, inter-firm relationships have increasingly become a core component. They constitute valuable capital because they provide access to capabilities and resources that may otherwise be unavailable (Koka and Prescott, 2002). As reviewed in the construction industry, partnering is becoming a trend in transition in the UK, this method drives individual firms into a nexus of connections, thus becoming a point of an extended network. Every firm could access more external resource in working practice by collaborating with several long-term partners. To improve performance by managing inter-firm relationships successfully in the construction industry, Welling and Kamann (2001) recommend the following actions:

- Structuring relationships in such a way that there are frequent and durable interactions among specific individuals.
- Appointing account managers and asking firms that are part of the permanent network to do the same should create recurrent meetings among people and this, in turn, should stimulate collaborative relations.
- Monitoring current behavior and experiences and pooling this information enables project managers to share experiences.

Based on the review of the above literature, it can be suggested that external business networking activity enables individuals to become aware of new technologies, which may be relevant to their own organizations. Consequently, networking is a social communication process, which encourages the sharing of knowledge among communities. In today’s business practice, knowledge is increasingly distributed both within organizations and across organizations (Swan *et al*, 1999).

## 4.2 Social capital: committed relations as resources

The review of the past sections demonstrates that committed relationships embed a firm in networks that are a valuable resource and lead to competitive advantages. When relationships in networks are examined as a valuable resource, social capital emerges as a suitable concept to deal with various relations and activities. The notion of 'social capital' is an additional ingredient to the already well-known economic conditions or elements that make up organizational capital: physical capital, financial capital and human capital. The 'traditional' types of capital determine only partially the process of economic growth and overlook the way in which the economic actors interact and organize themselves to potentially generate growth and development. Increasingly, it becomes accepted that the missing link is 'social capital' (Huysman, and Wulf, 2006). The concept of "social capital" has been used to explain a variety of social achievements and actions that other forms of individual-based capital (such as human and financial capital) are unable to explain. Social capital comprises "the norms and social relations embedded in the social structures of society that enable people to coordinate action and to achieve desired goals" (Narayan, 1999, p. 6).

According to Lin (2001), "Social capital contains three components intersecting structure and action: structure (embeddedness), opportunity (accessibility through social networks), and action (use)". In order to complete jobs effectively and efficiently, it seems the 'know-who' is valued almost as much as the 'know-how' (Gann and Salter, 2000). Burt (1992) distinguishes three types of capital: physical, human and social. Physical capital refers to the resources such as money and land that an individual has access to. Human capital is the personal knowledge, abilities and charisma that the individual has while working. Social capital is the network of individual contacts that the individual knows and the people known by the contacts. Burt (1992) explains social capital as "friends, colleagues, and more general contacts through whom you receive opportunities to use your financial and human capital" (p. 9).

Faraj (2001) suggests that the key difference between social capital and the other forms of capital is that social capital is embedded in the social realm. While other forms of capital are based on assets or individuals, social capital resides in the fabric of relations between individuals. Cohen and Prusak (2001) consider that a social network “consists of the stock of active connections among people: the trust, mutual understanding, and shared values and behaviors that bind the members of the human network and communities and make collaborative action possible”.

Focusing on the durability of relationships in networks, Bourdieu (1985) proposes social capital as “the aggregate of actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationship of more or mutual acquaintance and recognition” (p. 248). Social capital is accumulated labour. It has its own capitalists who accumulate it in the form of relationships, networks, contacts: ... the network of a relationship is the product of investment strategies, individual or collective, consciously or unconsciously aimed at establishing or reproducing social relationships which are directly usable in the short or long term ...”(p. 249). Social capital is about value derived from being a member of a society or community. By being a member, people have access to resources that non-members do not have. The key elements included in social capital are network ties of goodwill, mutual support, shared language, shared norms, social trust, and a sense of mutual obligation that people can derive value from (Huysman and Wulf, 2004). This is the main reason for adopting a network approach in managing business. By adopting a network perspective, the focus of main managerial concern shifts to relationship and cooperation across organizational boundaries. In fact, it is becoming increasingly common to describe the excess cooperation as social capital. Social capital deals with cooperation in groups and networks within groups of people (Paldam, 2000).

Coleman (1988) simply defines social capital as people’s ability to work voluntarily together, which is similar to the “networkability of organization”, proposed by Österle

(2000). Coleman (1990) claims that social capital possessed common features with human capital, while human capital refers individual ability; social capital refers collective ability of a group of people. From this understanding, Coleman considers that ‘social capital and human capital are often complementary’ (1994: 304).

Putnam (1995) goes further by describing social capital as the “features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit (p. 66)”. Networks, norms and trust are interrelated and essential parts of the theory of social capital in Putman’s study. Although Putnam’s research (1995) about social capital mainly focuses on civic engagement, in sociology, economy and other academic fields along with business practice, social capital has evolved and has been studied in many forms. Putnam (2000) also points out that the social capital embodied in trust-full ties is celebrated as a key source of collective prosperity.

Similarly, Flap (1995) defines social capital as a combination of network size, the relationship strength, and the resources possessed by those in the network.

Lin (1999) concludes that as a concept, social capital is rooted in social networks and social relations, and must be measured relative to its root. Therefore, social capital can be defined as resources embedded in a social structure which are accessed and/or mobilized in purposive actions. By this definition, the notion of social capital contains three ingredients: (1) resources embedded in a social structure; (2) accessibility to such social resources by individuals; and (3) use or mobilization of such social resources by individuals in purposive actions. Thus conceived, social capital contains three elements intersecting structure and action: the structural (embeddedness), opportunity (accessibility) and action-oriented (use) aspects (Lin, 1999).

The introduction of the concept of “social capital” is important as it distinguishes a collection of individual organizations from networked firms. It makes people work together in a collaborative way in order to achieve shared aims as well as their own

aims.

### **4.3 Managing knowledge in networks and collaboration**

Traditionally, economic systems are based on independent firms typically found in capital-intensive industries. In the last thirty years networks based systems have emerged within high technology, high growth industries. These horizontal networks of organizations have become very specialized while at the same time expanding their special capabilities through collaboration with other network specialists (Brannback *et al.*, 2003). Connectivity to a network and competence at managing networks have become key drivers of a new business logic (Seufert *et al.* 1999), Knowledge Management, in today's knowledge era, has become a key process for establishing and sustaining networkability, new approaches to the theory of the firm are consisting primarily of business networking as major trends for companies with virtual organizing and Knowledge Management as inherent elements (Hafeez 2002).

The previous literature review has demonstrated that network perspectives have identified issues untouched in traditional economic systems. When the focus shifts from managing organization as independent to managing organizations in networks, Knowledge Management develops further, based on the collaborative working environment. As discussed in the last section, the notion of a network approach leads to the consideration of collaborative working across organizational boundaries. The organizational work relations leads to the development of supportive roles, communal relationships, high confidence in others, free exchange of knowledge, and help-seeking behaviours (Jones & George, 1998). Cohen and Prusak (2001) consider that social capital should be regarded as the main approach to improve Knowledge Management in organizations.

Wathne *et al* (1996) also confirmed in their empirical study that committed working relations leads to increased openness and more effective knowledge transfer between partner representatives of organizations engaged in collaborative relationships.

Huysman and Wulf (2004) argue that investing in social capital will result in organizational members inherently motivated to share knowledge. This motivation is derived from being a member of a community where shared norms, trust, cognitions and experiences stimulate 'goodwill' and reciprocity.

As discussed in the previous section, every organization is associated with certain networks which are essential for their survival and success in business. The previous review also confirmed that people, committed relationships and different recourses toward shared aims are essential for successful collaborative working. A variety of knowledge from participants has become the most valuable recourses and main reason in collaborative working, therefore, Knowledge Management in networks is essential for Knowledge Management development because "effective Knowledge Management requires creating a supportive, collaborative culture..."(Ndlela and du Toit 1999). Following the network approach of managing organizations, relevant concepts have been discussed such as managing knowledge across boundaries, Knowledge Management in strategic alliance, even knowledge network, in academia and in practice.

As reviewed in Chapter Two, knowledge is socially constructed (Nonaka, 1994) and tacit essentially (Polany, 1966). Knowledge Management is "a discipline that promotes a collaborative and integrated approach to the creation, capture, organization, access and use of an enterprise's information assets" (Myburgh, 2003 ). When knowledge is recorded in a system it becomes explicit and codified (Zack, 1999). Recorded knowledge is often not re-used (Davenport and Prusak, 1998). Business practices have demonstrated Knowledge Management failure, due to ignoring the social and tacit dimensions of managing knowledge; some organizations

invested heavily on what they called Knowledge Management, but actually those investments are more for information management. In reality, people seek knowledge support from other people via their social network rather than electronic networks because Knowledge Management is typically virtual, intelligent and networked (Huysman, and Wulf, 2006). Thus, though recently the social capital and social networks have been drawing more and more attention in the field of Knowledge Management (e.g. Lesser, 2000; Cohen and Prusak, 2001; Adler and Kwon, 2002). By acknowledging the importance of social capital, these works confirm that well developed social networks and social capital bring more Knowledge Management benefits. The increasing attention to the concept of Knowledge Management across organizational borders is not only a result of the growing recognition of the value of knowledge work but also because of the increasing complexity of work and speed at which changes take place (Huysman, and Wulf, 2006).

Viewing firms in a network from Knowledge Management perspective, Seufert *et al* (1999) consider that they are based increasingly on knowledge-seeking and knowledge-creation rather than just devices for processing information, making decisions, and solving problems. The integration of networking into Knowledge Management yields great benefits. The openness and richness of networks are believed to foster a fertile environment for the creation of entirely new knowledge, while also accelerating the innovation rate (Seufert *et al.* 1999).

Seufert *et al* (1999) use the term of 'Knowledge Networking' to signify a number of people, resources and relationships among them, who are assembled in order to accumulate and use knowledge primarily by means of knowledge creation and transfer processes, for the purpose of creating value. Seufert *et al* (1999) distinguish "knowledge networking" into two categories: "intentional knowledge networks" and "emergent knowledge networks". "Intentional knowledge networks are explained as networks that are built up from scratch, whereas emergent knowledge networks already exist but have to be cultivated in order to become high-performing. In this

way, a network may evolve whose participants share a common language, and a common set of values and objectives. This (social) network is backed up and transformed by information- and communication technology. As this network of knowledge-resources is continuously being augmented by knowledge gained from learning situations, a Knowledge Network should be regarded as a dynamic structure rather than as a static institution” (Seufert *et al* 1999)

Hafeez (2002) advocates the development of “new networked and knowledge based organizations” based on his empirical study. Viewing project teams as virtual organizations, knowledge exchange in project teams has been regarded as a vital element in “virtually organizing” business. Gill (2002) considers that knowledge networking is becoming a key element in sustainable development, which is rooted in the principles of interdependence and mutually beneficial economic growth, supporting participation, cooperation and empowerment

Considering the construction industry in the UK, learning, innovation, expertise, which are all key elements of Knowledge Management, have been emphasized from the very beginning of the transition. They repeatedly point out the interdependence between partnering and Knowledge Management activities across organizational borders. Johnston and Lawrence (1988). suggest that “value-adding partnerships” allow firms to improve their knowledge base while traditional systems limit the Knowledge Management of firms and raise transaction costs on information access. Egan (1998) points out that “The repeated selection of new teams, in our view, inhibits learning, innovation and the development of skilled and experienced teams”, “A team that does not stay together has no learning capability and no chance of making the incremental improvements that improve efficiency over the long term” (Egan 1998, p14, p17). This echoes suggestions made by Latham (1994), in which trust and committed relationships for maximising the effectiveness of each participant’s resources and expertise have been viewed as a foundation necessary to achieve specific primary objectives. Latham (1994) also recommend that more widely



“partnering” – collaborative relationships between clients, contractors, sub-contractors and suppliers – will promote innovation. Shortly after the Latham report, a report from CRISP (1995) suggested that innovation could be achieved by closer involvement of clients and improved mechanisms for knowledge access.

In order to integrate information regarding good practices, innovations and experience for any organisation or individual connected with the construction industry, Egan (1998) suggests that an objective and impartial “Knowledge Centre” should be set up.

### **4.3.1 Communities of practice and networks of practice**

The concept of a community of practice (CoP) emerges as having a dominant role in Knowledge Management practice. A community of practice is an emergent social collective where individuals working on similar problems self-organize to help each other and share perspectives about their work practice, resulting in learning and innovation within the community (Brown & Duguid, 1991; Wenger, 1998).

‘Communities of practice help foster an environment in which knowledge can be created and shared and, most importantly, used to improve effectiveness, efficiency and innovation’ (Lesser and Everest, 2001, p.41). A community of practice is defined as an activity system about which participants share understandings concerning what they are doing and what that means in their lives and for their community. Thus, they are united in both action and in the meaning that that action has, both for themselves, and for the larger collective (Lave and Wenger, 1991, p98). The Community of Practice is organized from different business units in which individuals who have similar work-related activities and interests share their experience by web space or meeting (Wenger, 1998). Brown and Duguid (2001) adopt this concept to analyse knowledge “stickiness” or “leakiness” within organizations and view community of practice as critical when sharing knowledge. In fact, this concept has been utilized to

promote knowledge sharing within large organizations, especially international business, to increase competitive advantage and facilitate organizational learning (Davenport & Prusak, 1998).

When knowledge within business units cannot meet the challenge of problem solution, the community of practice exceeds organizational boundaries and involves several other relevant organizations. Although people could search for information or codified knowledge, the quickest way to accomplish a job is to ask people who have experienced similar problems (no matter whether those people are within the organization or not).

The development of cooperation and knowledge exchange across organizational boundaries has been accepted as one of the drivers of technology diversity. As reviewed in the last section, business networks are enabling new organizational forms and sustaining cross-organizational knowledge sharing. This new form of business structure is loosening the constraints of organizational structure and physical proximity to allow connectivity between individuals who would otherwise find it difficult to identify others with similar interests, and to initiate and sustain contact. However, participation in extra-organizational networks benefits organizational members because it provides access to information, expertise, and new ideas across organizational and functional boundaries (Faraj and Wasko, 2001). Access to these autonomous, extra-organizational networks poses novel challenges to organizations attempting to manage their knowledge resources and control their boundaries (Pickering & King, 1995), therefore, in constructing, supporting and aligning communities of practice, Lesser and Everest (2001) consider that managers play a critical role in order to exploit human capital more fully and to develop innovative capacity.

Extra-organizational networks focused on practice frequently emerge in fields where the pace of technological change requires access to knowledge and resources that are

unavailable within any single organization (Powell *et al*, 1996). These work-oriented extra-organizational networks are defined as “networks of practice” (Brown and Duguid 1991, Faraj and Wasko, 2001). A network of practice is a self-organizing open activity system focused on work practice that exists primarily through electronic communication. The concept of Network of Practice is similar to a community of practice in that it is a social space where individuals working on similar problems self-organize to help each other and share perspectives about their practice.

Occupational and professional networks are important inter-organizational forums for learning and innovation (Swan *et al.*, 1999). In a network of practice, people working within occupations, or having similar interests congregate to engage in knowledge exchange about the problems and issues that are common to their occupational community and shared practice (Faraj and Wasko, 2001). From this perspective, flows of knowledge are seen as inextricably linked to social relations developed through shared practice (Swan *et al*, 2002). Knorr-Cetina (1999) noticed that in a network of practice, while scientists within disciplines can communicate and collaborate with colleagues globally, they may fail to collaborate across disciplines, even at a local level. The construction industry shares the same features. It is hard to integrate knowledge networks across a variety of technology clusters and project knowledge is easy to lose when the context for certain knowledge is changed along the cease of a project.

Previous sections have confirmed that partnering creates a social context which drives Knowledge Management by connection across organizational borders. The continuing partnership enables long term relationship development between personnel from different companies, which have different knowledge basis, solutions for similar problems. Also collaborative working attitudes promote knowledge exchange and learning activities which are the basis for innovative working solutions due to low risks from competition and mutual benefits from shared aims. As some knowledge is very complex and embedded in context, long-term cooperation can demolish barriers that would otherwise arise from these elements. Meanwhile, benefits from Knowledge

Management between partners leads to more connections and long-term collaboration. Thinking organizations in collaboration networks, the organization's boundaries are becoming blurred; lots of Knowledge Management activities cannot be explained by formal organizational charts or job flow systems. The sharing of knowledge requires social organization and governance. Traditional organizational forms (markets and hierarchies) show serious deficits in organizing the complex nature of knowledge (Jones *et al.*, 1997). For this reason the working relationship should be introduced and analysed following the development for sharing knowledge across organizational boundaries. The informal relationships developed from various resources are becoming more and more important in explaining the patterns of people seeking supportive knowledge and expertise. Social Network Analysis is a powerful tool in analysing these informal relationships and explain certain phenomena that cannot be explained from formal organizational systems.

Nevertheless, “community of practice” and “network of practice” are useful practical tools in addressing Knowledge Management in network environment. Though they did discuss how to manage knowledge in different network contexts which could be used in most practical cases, they do not meet the challenges set by project environments. Community of practice allow discussion of Knowledge Management activities by which people share their experience and knowledge, networks of practice take into account the work oriented knowledge sharing activities across organizational boundaries due to social connections. But in project environments, knowledge and experience are much diversified which involves a large number of totally different techniques, also the time scales have been ignored in those two frameworks. In project environments, the concept of “knowledge contribution” should be introduced, when people involved in project work on solutions. They are more likely to ask each other's knowledge contribution or expertise support rather than learning from them, though no one could deny that they learn in that process, learning is not their main purpose, this could make distinct knowledge contributions from those two frameworks. Thus, the discussion of knowledge contributions in project environments

will address the limitations of these two frameworks.

## **4.4 Social Network Analysis approach**

The literature review on networks has shown that network perspectives enable the analysis of organizational behaviour beyond its boundaries to a large extent. In fact, networks have been utilized as an approach to explore all the realm of inter-organizational ties (Grabher and Ibert, 2006). The adoption of a social network approach is to look at interactions between people – defining and articulating them, looking at the patterns of interconnection they create, and coming to understand what such patterns mean for the group under study. It promotes an empirical, unbundling of social phenomena (Haythornthwaite 2005).

### **4.4.1 Introduction to Social Network Analysis**

The Social Network model was created based on criticisms of neo-classical economics models proposed by Williamson, in which transaction activities are directed by bounded rationality and opportunism (Gordon and McCann 2000). The ‘social-network model’ proposes that there is more order to inter-firm interactions and less order to intra-firm interactions than the economic models would imply (Granovetter, 1985). Social networks of certain strong interpersonal relationships can be stronger than firm boundaries, with the result that many inter-firm social interactions may be stronger than their intra-firm counterparts (Gordon and McCann 2000). People use their social network as important resources for information and knowledge to accomplish their job.

Freeman (2005) suggests that that Social Network Analysis focus on two structural

patterns of the ties that link social actors. The patterns can

1. reveal subsets of actors that are organized into cohesive social groups and
2. reveal subsets of actors that occupy equivalent social positions, or roles.

Therefore, the actor-by-actor ties provide basic data for Social Network Analysis.

By using a Social Network Analysis approach, it is possible to understand organizations and manage informal networks systematically (Cross and Prusak, 2002). The key issue that distinguishes Social Network Analysis from other analyses and management methods is that it draws attention to informal network in the work place. Basically, the role of Social Network Analysis is to measure and visualize relationships and flows between people, groups, organizations, computers or other information/knowledge processing entities.

McCarty (2001) explains that Social Network Analysis (SNA) is both a theoretical perspective and a set of methods. In terms of theory, SNA extends and complements traditional social science by focusing on the causes and consequences of relations between people and among sets of people rather than on the features of individuals. In terms of method, SNA focuses on the measurement of relationships between people. In use of relational concepts, the following are important:

- Actors and their actions are viewed as interdependent rather than independent, autonomous units. Relational ties (linkages) between actors are channels for transfer or "flow" of resources (either material or nonmaterial);
- Network models focusing on individuals view the network structural environment as providing opportunities for, or constraints, on individual action;
- Network models conceptualize structure (social, economic, political, and so forth) as lasting patterns of relations among actors (Wasserman and Faust, 1994).

## 4.4.2 Analyzing social networks

There are two approaches to analyzing network attributes in Social Network Analysis. The first one is the “sociocentric” network approach which focuses connections in defined whole network. For example, supportive connections in a group of researchers, helping activities in a classroom of people, by measuring relationships between all units, the analysis reveals the properties of relationships in the whole network. The boundary of “sociocentric” analysis is pre-set by researchers.

The second one is the “ego-centric ” approach. Starting from a specific unit for research, this method collection relational connections with other “alters” (chosen according to the research aims), which later determine the final boundary of the whole network. It is a method to study how relational influences produce efforts on the individual.

Though the two approaches differ in research focus, they are closely connected. Ego-centred network research focuses on the single individual and its alters in whole network. Thus, whole-network research focuses on all relationships and attributes arising from all egos. This research adopts a whole-network approach, because this research is interested in the comparison of two types of networks (competitive working and collaborative working), and how the two networks differ in their whole-network measures, though some egos will be picked up for comparison purposes. Therefore, full network methods were adopted which requires collecting information about each actor's ties with all other actors. In essence, this approach is taking a census of ties in a population of actors – rather than a sample. In fact, social network analysts rarely draw samples in their work. Because network methods focus on relationships among actors, actors cannot be sampled independently to be included as observations. If one actor happens to be selected, then we must also include all other actors to whom our ego has (or could have) ties. As a result, network approaches

tend to study whole populations by means of census, rather than by sample (Hanneman & Riddle, 2005).

Analysis of sociocentric network data focuses on the structural properties of relations, rather than the individual relationships themselves. This study adopts a socialcentric network approach to explain how the different working connections between project team in collaborative/competitive context influence working process. The properties of the whole network within projects are to be used to explain the different working philosophy in different context. Ego's attributes are to be taken into account but the final focus is still the whole project network.

The basis for sociocentric network analysis is a matrix where the rows and columns represent the members of the group being studied, and each cell of the matrix contains a measurement of some tie between those members. The diagonal of the matrix is the intersection of each member (individual or organization) with itself, and is often ignored in analytical routines. Asking people about their interaction with others – their communications, their exchange of advice and other resources – remains the source of most sociocentric network data (McCarty, 2001).

### **4.4.3 Software comparisons**

There are a number of computer software products available to analyze social network data, including INSNA IKNOW. The specifications of each software product are slight different though the main principle is to simplify data analysing and presentation. Some software such as VISIONE, NETVIZ are solely for the visualization of data. For further detailed comparisons of software features, refer to Huisman and Duijin (2005).



Based on previous work, Huisman and Duijin (2005) conclude that Social Network Analysis focuses on the following categories in order to explain relationships in a meaningful way.

- Structure and location: “centrality” (Everett and Borgatti, 2004) and cohesive subgroups (cliques);
- Roles and positions: structural equivalence, block-modelling (Doreian, Batagelj, and Ferligoj, 2004), eigendecompositions;
- Dyadic and triadic methods;
- Social methods: exponential random graph models (Wasserman and Robins, 2004) QAP (Quadratic Assignment Procedure) correlation, statistical analysis of network evolution (Snijders, 2004). (cited from Huisman and Duijin, 2005: p.275 ).

Huisman and Duijin (2005) categorise software according to five groups of procedures:

- Data entry and data manipulation;
- Visualization techniques;
- Social Network Analysis routines, divided into three types of methods:
- Descriptive methods to calculate (simple) network statistics (e.g. centrality or transitivity);
- Procedure-based analysis based on more complex (iterative) algorithms (e.g. cluster analysis or eigendecompositions);
- Statistical modeling based on probability distributions (e.g., exponential random graph models or quadratic assignment procedure (QAP) correlation) (Huisman and Duijin, 2005 p274-5).

According to Huisman and Duijin (2005), UCINET 6 is “a comprehensive program for the analysis of social networks and other proximity data. it is probably the best-known and most frequently used software package for the analysis of social network data and contains a large number of network analytic routines” (p.275)

This research uses UCINET 6.138, because UCINET is the most popular software in this Social Network Analysis research, this popularity could make this research easily duplicated in other fields and industry for further research. This software contains a large number of network analytic routines for the detection of cohesion for a variety of analyses such as centrality and ego network. It has integrated NetDraw to visualize data and PAJEK, which is a package for large project network analysis.

#### 4.4.4 Implementation of Social Network Analysis

In order to explain the implementation of Social Network Analysis, it is necessary to introduce some relevant concepts and example before further discussion. The following definitions are taken from “Introduction to Social Network Methods” by Hanneman and Riddle (2005).

##### **Matrix:**

A matrix is a basic form to represent relational data, here is an example from “Introduction to Social Network Methods” by Hanneman and Riddle (2005).

Who reports liking whom?				
	Choice:			
Chooser:	Bob	Carol	Ted	Alice
Bob	---	0	1	1
Carol	1	---	0	1
Ted	0	1	---	1
Alice	1	0	0	---

*Table 4.1 social relationship matrix*

The matrix is a quantitative method used to present data and is referred as “sociomatrices” in Social Network Analysis. Sociomatrices data sets could be used for Social Network Analysis software. Sociomatrices display rows and columns that represent individuals and numbers or symbols in the cells and show the number of connections linking to those individuals (Hoffman, 2001). The matrix above shows connections within the group. It shows a structure of connections, within which the actor is embedded. Actors are described by their relations, not by their attributes. Conventional data focuses on actors and attributes while network data focus on actors and relations. The relations themselves are just as fundamental as the actors that they connect.

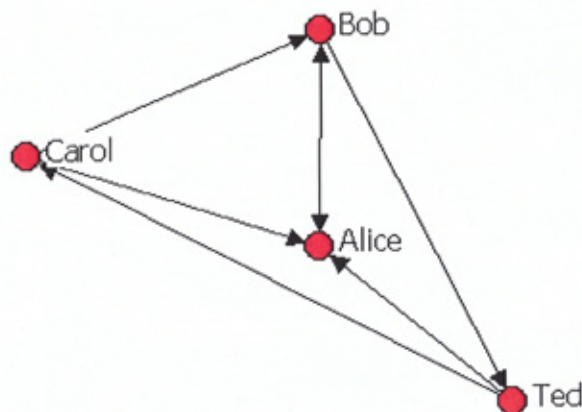
Every member in this matrix is called “actor”. According to Wasserman and Faust (1994), an actor is defined as a social entity in Social Network Analysis. Actors could be discrete individuals, corporate, or collective social units, even a nation. The term “actor” doesn’t mean that the social entities necessarily have to “act”.

The connections between actors in that matrix are “relational ties”. Wasserman and Faust (1994) explain this term as social ties connecting two actors. They provide the following examples for relational ties in Social Network Analysis research:

- Evaluation of one person by another (for example, expressed friendship, liking, or respect);
- Transfer of material resources (for example business transactions, lending or borrowing things);
- Association or affiliation (for example jointly attending a social event, or belonging to the same social club);
- Behavioural interaction (talking together, sending messages);
- Movement between places or statuses (migration, social or physical mobility);
- Physical connection (a road, river, or bridge connecting two points);
- Formal relations (for example, authority);
- Biological relationship (kinship or descent);

The datasets (sociomatrices) provide raw data to present the actors and ties in a graph known as a “sociogram”. The sociogram provides a qualitative method to present data in social network. When visualizing the connections of this matrix, some concepts from graph theory have to be introduced. Graph theory is one of the younger branches of mathematics, it is fundamental to a number of applied fields, including operations research, computer science, and Social Network Analysis. In mapping actors and relational ties, researchers specify this graph in Social Network Analysis as a social-gram.

Taking the matrix in figure 4.1 as an example:



*Figure 4.1 visualization of matrix*

Every entity in this graph is called a “node”. The ties in this graph are also called “links”, “lines” or “edges”, and could be directed or not. Graphs composed of directed edges are themselves called directed graphs or sometimes digraphs. As a directed graph above, it is clear that only Bob and Alice like *each other*; “liking” reported by others are all “one way” connections. Also it is clear Alice is the most popular one in this group because she enjoys the highest “degree” of connections in this group. Every line connected to her is counted as one degree.

Wasserman and Faust (1994) point out that “the focus on relations, and the patterns of relations, requires a set of methods and analytic concepts that are distinct from the methods of traditional statistics and data analysis” (p.3), “the unit of analysis in network analysis is not the individual, but an entity consisting of a collection of individuals and the linkages among them” (p.5). Therefore, “one cannot use multiple regression, t-tests, canonical correlations, structural equation models, and so forth, to study social network data”. Social network data require measurements on the ties among the units in a network so that an entire body of measures has been developed for analysis of the relationships at the individual actor, subgroup, and network level.

Social Network Analysis provides measurements to identify the importance of individual actors to explain why they are influential (or not). By locating individual actors in a network, their role of prominence could be explained. Cross and Prusak (2002) suggest that this analysis provides managers with an insight into the transformation of an ineffective network into a productive one.

In analysing business networks, Cross *et al.* (2002) have identified four roles for addressing individual attributes in the function of networking exchange: central connectors, information brokers, boundary spanners, and peripheral specialists.

- “Central connectors” link together the most people in a network. As a consequence, central connectors know who is likely to know information sought by other members of the network;
- “Information brokers”, also known as knowledge brokers (Burt, 1992), keep different subgroups together. By communicating across these subgroups, they prevent one network from fragmenting into several smaller networks;
- “Boundary spanners” have connections with other groups or organizations primarily outside of the network under consideration. They therefore provide access to different kinds of expertise;
- “Peripheral specialists” provide in-depth expertise to any member of the network. Alternatively, some network members may be peripheral because of poor

integration into their network of colleagues.

This section merely presents some of the basic concepts of Social Network Analysis; relevant measurements of social network are introduced in Chapter 5 which is concerned with research design.

The application of Social Network Analysis in construction industry research is very limited. Only a limited number of researches have used Social Network Analysis so far. Loosemore (1999) used working records to quantify all communication between firms in project crises. His research collected all communications between project parties in a project crisis period, including phone calls, fax, emails and face to face discussions. Frequency is a means to establish connections between parties in Social Network Analysis. However, the problem in his research is that the communication cannot be explained in a meaningful way. For example, when firms have trust in each other they may not communicate so often about certain issues in a project, because they are supposed to know each other's thinking very well. People may make another call if they forget something in the first call. Therefore, this method cannot fully explain the quality of inter-firm relationships such as supportive activities based upon trust.

Pryke (2004) analysed performance intensive networks and design development networks based on contractual network analysis. But these three networks are generally formal networks, the main advantages of Social Network Analysis in social science is to establish "informal relationship network", in order to address the social dimension rather than the economics dimension to explain why and how certain situations happen in certain contexts. Social Network Analysis is designed to investigate phenomena which are hard to explain from formal working relations. Normally the informal network cannot be drawn from an organizational chart or a set of transactional relationships. The analysis of formal networks is relatively easier but the ignorance of informal networks will lead to blind points in explaining some

phenomena in reality. Another issue with regard to Pryke's research is how he collected data for establishing the several networks, the questions used in collecting data to establish those networks could be very similar and hard to distinguish from each other.

## **Summary**

This chapter briefly introduced the network perspective for analysing organizational activities in a social context. Based on a review of the last chapter, it is clear that the adaptation of network perspectives will help to explain certain phenomena which are difficult to otherwise explain within organizational boundaries. Social networks and committed relationships were reviewed in this chapter because they are key elements in distinguishing a collection of individuals (organization) from an interactive network in which transactions take place.

A network perspective allows for the analysis of inter organizational networks and intra-organization networks. Indeed it allows the multiple units of analysis – individual, group, and organization. The social capital and social networks between organizations promote knowledge and information flowing across organizational boundaries.

In the knowledge era, the knowledge creation process includes not only individual actors, but also links to larger units through processes of socialization and justification because knowledge is socially constructed (Nonaka and Takeuchi 1995).

Finally, Social Network Analysis was briefly introduced, but for more detailed measurements and data collection procedure please refer to the Research Design chapter.

# **Chapter 5 Research design and development**

The purpose of this chapter is to discuss the assumptions on which the research is based and to justify the methodological approach selected. This chapter starts with a debate about different research approaches. Then the different concepts of research paradigms are reviewed. Qualitative and quantitative methods are discussed and assessed as to their suitability to support the research questions, and a suitable research paradigm and design is detailed to justify the selection of suitable research techniques.

## **5.1 Philosophical debate**

Research methodology refers to the way in which one attempts to investigate and obtain knowledge about the real world (Burrell and Morgan, 1979).

Burrell and Morgan (1979) argue that 'social scientists approach their subject via explicit or implicit assumptions about the nature of the social world and the way in which it may be investigated' (p.1). They conceptualise four paradigmatic assumptions in the social science approach to empirical research, which are ontology, epistemology, human nature and methodology, and range from subjectivist to objectivist.

Ontological assumptions have to deal with the phenomena or objects to be investigated. Burrell and Morgan (1979) distinguish between the ontology of nominalism and realism. They state that the nominalist position revolves around the assumption that the social world external to individual cognition is made up of



nothing more than names, concepts and labels which are used to structure reality. Realism assumes that the social world external to individual cognition is a real world made up of hard, tangible and relatively immutable structure.

Epistemology involves assumptions that are concerned with knowledge and how to understand and communicate it. Burrell and Morgan (1979) distinguish between epistemology of positivism and antipositivism. They consider that positivism seeks to explain and predict what happens in the social world by searching for regularities and casual relationships between its constituent elements. Antipositivism suggests that the social world is essentially relativistic and can only be understood from the point of view of the individuals who are directly involved in the activities which are to be studied. Antipositivists reject the standpoint of the neutral observer, which characterizes positivist epistemology, as a valid vantage point for understanding human activities. They maintain that one can only understand by occupying the frame of reference of the participant in action. One has to understand from the inside rather than outside.

Methodology is the way in which one attempts to investigate and obtain knowledge about the real world (Burrell and Morgan, 1979). Furthermore, Gummesson (2000) develops their concepts as that positivistic paradigm is the foundation for quantitative research and the hermeneutic paradigm for qualitative research.

However, science offers a special approach to the discovery of reality through personal experience. It offers a special approach to the business of inquiry. Epistemology is the science of knowing; methodology, which is a subfield of epistemology, might be called the science of finding out (Babbie, 2001).

This research attempts to identify some issues as they occur in practice, how organizations in a project environment manage their knowledge, how knowledge integration facilitates collaboration and how collaborative working promotes

knowledge sharing. In order to obtain information to explore causalities and correlation of these issues, a proper research design and data collection method must be adapted for the validity and reliability of any conclusions. These will be discussed in the following sections.

### **5.1.1 Inductive and deductive theory**

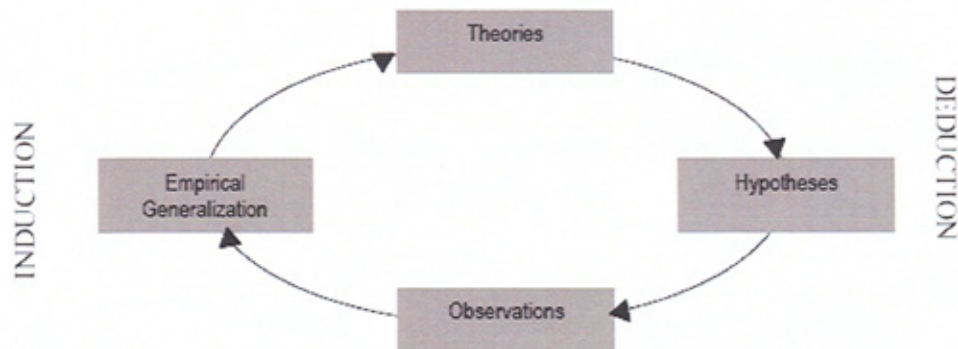
Logicians distinguish between inductive reasoning (from particular instances to general principles, from facts to theories) and deductive reasoning (from the general to the particular, applying a theory to a particular case). In induction one starts from observed data and develops a generalization which explains the relationships between the objectives served. On the other hand, in deductive reasoning one starts from some general law and applies it to a particular instance (Beveridge. 1950, p113).

Therefore, the basic research route in reasoning a phenomenon could be divided into two means:

- Inductive reasoning moves from the particular to the general, from a set of specific observations to the discovery of a pattern that represents some degree of order among all the given events. But sometimes the discovery doesn't explain why the pattern exists, just that it does. (Babbie, 2001)
- Deductive reasoning moves from the general to the specific, it moves from (1) a pattern that might be logically or theoretically expected to (2) observations that test whether the expected pattern actually occurs. The deduction begins with 'why' and moves to 'whether', while induction moves in the opposite direction. (Babbie, 2001)

The two methods construct a logical circle and drive science research to their aims:

explore and explain the world.



*Figure 5.1 Inductive-deductive developments*

(Adapted from Wallace, 1971)

This research starts from literature review and existing theories, to construct initial aim and objectives in order to examine Knowledge Management between collaborative/competitive working organizations in the construction project process. Then this research moves to data collection which includes case study and questionnaire survey approaches. A final conclusion identifying all relevant issues is formulated.

### **5.1.2 Exploratory research vs. descriptive research**

Both exploratory and descriptive research are categories of research, which are classified by the research objectives (Clask, *et al*, 1995). Exploratory research is concerned with discovering the general nature of the problem and the variables that relate to it. Descriptive research is focused on the accurate description of the variables in the problem model (Hawkins & Tull, 1994).

Both of the research methods are used in this project which is to be discussed in detail in the next section

### **5.1.3 Research paradigm**

Burrell and Morgan (1979) suggest four research paradigms within sociology. The four paradigms are: radical humanist, radical structuralist, interpretative and functionalist. The first pair of these have a distinctly sociological agenda, and it is the last pair—that reflect the perceived nature of society—that are appropriate for discussion here. The functionalist paradigm has provided the dominant framework for the conduct of academic sociology and the study of organizations. Its philosophic antithesis is the interpretative paradigm. Burrell and Morgan (1979) consider the interpretative paradigm as seeking explanation from within the realm of individual consciousness and subjectivity, within the frame of reference of the participant as opposed to the observer of action.

Similarly Amaratunga and Baldry (2001) conclude that positivism and interpretivism are two distinct philosophical approaches.

The positivist approach, often linked with quantitative research, believes that the subject under analysis should be measured through objective methods rather than being inferred subjectively - through sensation, reflection or intuition (Remenyi *et al.*, 1998). Among the major implications of this approach are the need for independence of the observer from the subject being observed, and the need to formulate hypotheses for subsequent verification. Positivism searches for causal explanations and fundamental laws, and generally reduces the whole into its simplest possible elements in order to facilitate analysis (Remenyi *et al.*, 1998). By using this approach, the researcher is external to the events being examined such that measures taken are

objective. Researchers focus on facts and search for cause and effect

The interpretivist or phenomenological approach, understands reality as holistic, and socially constructed, rather than objectively determined. Susman and Evered (1978) talk of an "epistemological crisis" in management research which has arisen out of the application of the positivist model of science in the social sciences to reflect interpretivism, an approach which arose in the last half of the twentieth century. According to this philosophy, the researcher should not gather facts or simply measure how often certain patterns occur, but rather appreciate the different constructions and meanings people place upon their own experiences and the reasons for these differences. The interpretative approach tries to understand and explain a phenomenon, rather than search for external cause or fundamental laws (Remenyi *et al.*, 1998).

Theme	Positivist paradigm	Interpretivism paradigm
Basic belief	The world is objective and external, the observer is independent	The world is socially constructed and subjective, observer is part of what is observed Science is driven by human interests
Research intention	Focus on facts Look for causality and fundamental laws Formulate hypotheses and test them	Focus on meanings Try to understand what is happening Look at the totality of each situation Develop ideas through induction from data

*Table 5.1 Key distinctions of positivist paradigm and interpretative paradigm*  
(Adapted from Easterby-Smith et al. 1994)

Remenyi *et al.* (1998) assert that positivism and interpretivism are not totally different in terms of their impact on research, and in the generalisation of findings. Both approaches need a convincing argument that the findings are valid before these findings are accepted as a valuable addition to the body of knowledge. Ultimately, it may be more useful to see these two approaches as complementary rather than as two opposite extremes (Remenyi *et al.*, 1998).

### **5.1.4 Research design**

In order to generalize findings of this research, an appropriate research design is to be constructed considering all variables in social context and their interrelationships.

According to Oppenheim (2003), the term research design here refers to the basic plan or strategy of the research, and the logic behind it, which will make it possible and valid to draw more general conclusions from it. Thus, the research design should review how the sample would be drawn, what data it must contain, what comparisons would be made, what variables would need to be measured (when and at what intervals), and how these measures will be related to external events. Research design is concerned with making problems researchable by setting up studies in a way that would produce specific answers to specific questions. Good research design should, above all, make it possible to draw valid inferences from data in terms of generalization, association and causality (Oppenheim, 2003).

In order to find associations and causalities between Knowledge Management, knowledge integration, organizational relationships, collaboration and competitiveness from Social Network Analysis perspective, and generalize the findings at final stage. The aim of this research is to compare knowledge integration in two different working environments: namely, a collaborative environment and a more traditional, competitive one.

In order to achieve this aim, the research work used a Social Network approach. Accordingly, the following objectives were set

- A description of the present application of Social Network Theory, competitive/collaborative working and Knowledge Management in a construction project context.

- A comparison of different social network structures within two different procurement systems, which are competitive and collaborative procurement systems, to what extent and measures these two networks differ. This research proposes that a project with a collaborative partnering relationship would create different networks' structures from a non-partnering one. This will examine that how some social network attributes vary in different procurement systems. Varied network structure and attributes will be used to explain different knowledge transaction activities in the project process. The comparison will display the extent and under what conditions collaborative working could lead to certain advantages and how to reinforce these issues to support the advantages. The social structural conditions which support collaborative working and knowledge integration will reduce non-collaborative behaviour, while fostering cooperation and support towards others.
- An investigation of knowledge integration features in two procurement systems from a Social Network Analysis perspective. This will be achieved by analysing individual organizations in the measures of centrality and density. This exploration will identify benefits and constraints of Knowledge Management in collaborative working within an inter-organizational extent from a Social Network Analysis perspective, and to conclude the key business characteristics of Knowledge Management within strategic partners supporting collaborative working in construction projects.
- A description of the role of social networks in terms of knowledge integration in collaborative working. This will be achieved by the following:
  1. Establishment of key knowledge roles in collaborative working partners, to ensure that knowledge reaches all the parties of a project that need them.
  2. Mapping existing pathways and patterns for knowledge flow between organisations in collaborative working projects.

This research design is to construct a valid and reliable data collection routine in a rigorous manner to answer the aim and objectives outlined above

### 5.1.5 Research techniques

Research techniques are the methods used for data collection and generalization. They involve the detailed data collection techniques in practice, for example, interview, by telephone or by postal questionnaire. The techniques used to collect valid data by correct and correlated questions are important in order to measure certain patterns in social sciences. Essentially, research techniques are concerned with measurement, quantification and instrument building and with making sure that our instruments are appropriate, valid and reliable (Oppenheim, 2003).

In general, data can be presented in two ways, quantitative and qualitative. The distinction between the two kinds of data is whether the data is presented in a numerical or non-numerical way. Every observation is qualitative at the outset, none of the observation data is inherently numerical or quantitative, but it is useful to convert them to a numerical form (Babbie, 2001). Smith (1991: p.3) describes the distinction between qualitative and quantitative data in terms of uniqueness and categorization:

*No one seriously argues that events or groups or people are not unique in at least some minor detail. Rather, the issue is whether objects share attributes so important for one's concerns that their unique features can be ignored. The real issue is whether we can categorize. After all, categorizing permits grouping, grouping permits case enumeration, and counts are intrinsically quantitative.*

Quantification often makes observations more explicit, easy to understand, and provides possibilities for statistical analysis. But on the other hand, some meanings can be lost in quantitative calculation. In addition to greater detail, qualitative data can be richer in meaning than quantified data. In order to keep richer information and explain the various relationships in this research, both qualitative data and quantitative data are used; quantitative data would be presented for visual impact in order to



simplify the comparison. But in essence it is qualitative research that is dominant as this study is looking for correlations of collaborative working and knowledge contribution across organizational boundaries. Social Network Analysis data comprises matrices which are quantitative presentations of qualitative issue, eventually the matrices are to be converted into graphs to illustrate the correlations and explain the research findings.

The research methods are developed from the conclusions of the literature review.

Table 5.2 outlines the main phases of research strategy.

Research stages	Results
Literature review	Research objectives: a priori constructions and relationships
pilot case study	Identify feasibility of research objectives; case study strategy.
Case studies	multiple cases, in depth and casual explanation of knowledge integration among organizations in different working conditions
Phase one analysis	Initial qualitative findings from case studies
Questionnaire survey	Quantitative support for qualitative data
Phase two analysis	In-depth analysis of qualitative and quantitative data, verification of research aim and objectives

*Table 5.2 The main phases of research strategy*

Understanding the philosophical positioning of research is particularly useful in helping researchers clarify alternative designs and methods for a particular research, and identifying which are more likely to work in practice (Easterby-Smith, 1991).

The philosophical approach underlying this research is a balance between positivism and interpretativism. This shows in the way the research questions were formed. Objectives were formulated to identify empirical evidence to match theoretical propositions. Remenyi *et al.* (1998) suggest that the world is essentially non-deterministic (in any absolute sense) and repeated positivist research will produce different results; a balanced approach is therefore more "realistic".

Furthermore, because an intention is to understand the holistic context of the project

practice of Knowledge Management, an "interpretative" approach would provide the means to interpret practice allowing a study of the various different meanings that organizations in construction projects give to the research objectives.

## **5.2 Research methods**

The actual research methods adopted must be considered along with research aims and objectives. Social Network Analysis is a method used to combine both qualitative and quantitative data. For this research, qualitative methods are used in the main but data quantification was used in order to clarify and support analysis. Although statistics on social phenomena often contain ambiguities, and conceal the social norms on which classifications are based (Prior, 1997), they may nonetheless sometimes have a certain value as background material in qualitative research.

### **5.2.1 Case studies**

The nature of the research would mean that intensive research methods are preferred, and case study would be selected as the main research strategy. This sets the concepts of Knowledge Management and exchange in relation to informal relationships in their "real life" context.

The case study is a research strategy which focuses on understanding the dynamics present within single settings. Yin (1994) defines the case study as "an empirical investigation into contemporary phenomenon operating in a real-life context". It is particularly valuable where the kind of control present in a laboratory is not feasible and not even ethically justifiable (Yin, 1994).

A case study may be characterised as a detailed examination of an event (or series of related events) which the analyst believes exhibits the operation of some identified general theoretical principle (Mitchell, 1983). A very important advantage of the case material lies in the richness of its detailed understanding of reality. Zonabend (1992) states that case study research is carried out by giving special attention to complexities in observation, reconstruction, and analysis of the cases under study and is done in such a way that it incorporates the views of the "actors" in the case under study.

The need for case study research is supported by epistemological and methodological discussions. That is, there is a need to study Knowledge Management in its project context and, more importantly, to uncover the mechanisms through which organisations in the knowledge chain will benefit.

Yin (1994) postulates that any research study, for it to be valid, should conform to, and "pass" certain design tests with regard to various levels of research validity. Yin (1994) refers to four design tests:

- Construct validity - establishing correct operational measures for the concepts being studied;
- Internal validity - establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships;
- External validity - establishing the domain to which a study's findings can be generalised;
- Reliability - demonstrating that the operations of a study - such as the data collection procedures can be repeated with the same results.

This research follows these steps to construct case study design to ensure that the research is relevant to the practice environment. Firstly, this research adopts Social Network Analysis as part of theoretical framework as well as measurement.

Secondly, this research reviews the informal working relationships in relation to knowledge sharing from several aspects. In the literature review stage, the research focus and domain were set. Finally, reliability comes from the repeatability of the same operation by analysing data using Social Network Analysis software.

Case studies can be single or multiple-case designs. Multiple cases strengthen the results by replicating the pattern matching, thus increasing confidence in the robustness of the theory. The use of multiple cases in this study underlines the complexity of the topic under investigation and develops the empirical evidence to support and sharpen the theory. The approach to the case studies involves theory building and verification rather than testing.

### **5.2.2 Methods chosen**

From the debate of qualitative and quantitative methods, the advantage of method combination has been justified.

Rossmann and Wilson (1991) confirm the advantage of the combination as:

- to enable confirmation or corroboration of each other via triangulation;
- to elaborate or develop analysis, providing richer details; and
- to initiate new lines of thinking through attention to surprises or paradoxes, “turning ideas around”, providing fresh insights.

The combination is also a means of triangulation of findings at final stage.

Denzin (1984) identifies four types of triangulation:

- data source triangulation, when the researcher looks for the data to remain the same in different contexts;
- investigator triangulation, when several investigators examine the same phenomenon;

- theory triangulation, when investigators with different viewpoints interpret the same results; and
- methodological triangulation, when one approach is followed by another, to increase confidence in the interpretation.

The present research uses data source triangulation, i.e. different data sources--projects based in competitive and collaborative working contexts, as a means of triangulation.

### **5.3 Social Network Analysis application**

Most methodological techniques are rooted in history and are rarely called “innovation”, but Moreno (1953) describes the sociogram as an innovation; this innovation later developed into sociometry and then the full scale of Social Network Analysis (Wasserman& Faust, 1994).

In the Social Network Analysis approach, the research uses network data rather than conventional data for analysing. The major difference between conventional and network data is that conventional data focuses on actors and attributes; network data focus on actors and relations. Network data are defined by actors and by relations (or "nodes" and "edges"). The “nodes or actors” part of the network data would seem to be pretty straight-forward. Other empirical approaches in the social sciences also think in terms of cases or subjects or sample elements and the like. There is one difference with most network data, however, that makes a big difference in how such data are usually collected -- and the kinds of samples and populations that are studied (Huisman & Duijin, 2005).

Following the development of Social Network Analysis, some software was developed with a fixed algorithm to save the researcher’s time. These software

products include UCINET, Pajek, NetMiner, STRUCTURE, MultiNet and STOCHNET. Among those, UCINET is probably the best-known and most frequently used software package for the analysis of social network data and contains a larger number of network analytic routines (Huisman & Duijin, 2005). This research adopted UCINET as the analytic means for the analysis of social network data in construction projects.

Basically, UCINET requires a matrix as basic data entry method, sometimes it needs a set of matrices to construct relationships among nodes. It provides analytic routines for *centrality*, *density*, *structural equivalence* etc. In order to visualize matrix data, there is a “NetDraw” function embedded in this program to present matrix data as graphs. Indeed, social network analysts use two kinds of tools from mathematics to represent information about patterns of ties among social actors: graphs and matrices (Hanneman & Riddle, 2005).

The two fundamental concepts in social network and graph theory are:

- Actors: social entities in Social Network Analysis, are discrete individual, corporate, or collective social units.
- Relational ties: the linkages between actors. Ties could be built up by a lot of means. For example, evaluation, biological relationship, physical linkages etc. (Wasserman & Faust, 1994)

Graphs have been widely used in Social Network Analysis as a means of formally representing social relations and quantifying important social structural properties. Lacobucci (1994) concludes the following reasons for adopting graph theory in Social Network Analysis

- Graph theory provides a set of vocabulary which can be used to label and denote many social structural properties. This vocabulary also gives us a set of basic concepts that allows us to refer quite precisely to these properties
- Graph theory gives us mathematical operations and ideas with which many of

these properties can be quantified and measured.

- Given this vocabulary and these mathematics, graph theory gives us the ability to test theorems about graphs and representations of social structure.

Graph theory gives a representation of a social network as a model of a social system consisting of a set of actors and the ties between them. When a graph is used as a model of a social network, points (called nodes) are used to represent the actors, and lines connecting the points are used to represent the ties between the actors (Lacobucci, 1994 ). The points could represent individual person or organization in the graph. The lines could be directed (with arrowheads) or undirected (without arrowheads). In an undirected graph, the lines represent connections between two actors without directional meanings. In directed graphs, also known as digraphs, the directed lines distinguish two actors from “sending” to “receiving” a connection, for example, supplying a commodity to another.

### **5.3.1 Network approaches and implications**

The broad majority of social network studies use either “whole-network” or “egocentric” designs. Whole-network studies examine sets of interrelated objects or actors that are regarded for analytical purposes as bounded social collectives, although in practice network boundaries are often permeable and/or ambiguous. Egocentric studies focus on a focal actor or object and the relationships in its locality (Marsden, 2005) ego-centred networks are defined by the relations emanating from a focal actor, or star, while whole networks are defined by the relationships among all individuals in an entire social system (Alba, 1982; Burt, 1980; Marsden, 1990; Wellman, 1988).

To start investigating a network, the network boundary becomes vital for research. In practice, social network studies often draw the boundaries around a population that is known, a priori, to be a network. Alternatively, a network analyst might take a more

"demographic" or "ecological" approach to defining population boundaries (Hanneman & Riddle, 2005).

This research utilizes a whole-network approach; all participants within the project process are considered at the beginning. Nodes presented in the research are organizational departments rather than individuals though all contacts are made through individuals. In fact, interviewees were selected from a set of functional teams according to their role. The interviewee sometimes may be from the same organization but different departments. In order to overcome the disadvantages of this and to view big complex organization as a single node as well as small and simple ones in social network, the main criteria for selecting interviewees are

- Familiar with the whole process
- Take main responsibilities on site in relation to the project process
- able to make decision in operational level

### **5.3.2 Measurements**

In constructing a Social Network model, certain measurements are taken into account according to research design to map the patterns of a Social Network model; these measurements are used for identification of actors' and links' properties within a Social Network model. The measurements are to represent how the actors in a Social Network model are connected and how they interactively influence each other. In this research, centrality and density were taken as measurements. Hanneman & Riddle (2005) consider that there are good theoretical reasons (and some empirical evidence) to believe that these basic properties of social networks have very important consequences



## Centrality analysis

Centrality is a structural attribute of nodes in a network, in Social Network Analysis practice; centrality is one of the most important and widely used conceptual tools for analysing social networks. Nearly all empirical studies try to identify the most important actors within the network. The centrality measurement is to identify who is the most important actor in a social network model. By measuring centrality of an actor, the importance and power influence can be analysed according to quantified data (Huisman & Duijin, 2005). The purpose of comparing centrality is to identify the “most important” actors in a social network, which is one of the primary uses of graph theory in Social Network Analysis (Wasserman & Faust, 1994). There are three approaches developed to measure centrality: *degree centrality*, *closeness centrality* and *betweenness centrality*.

According to Freeman (1979), the three basic concepts are:

- Degree: number of ties to others. Row or column sums of adjacency matrix .
- Closeness: the graph-theoretic distance of a given node to all other nodes. The sum of the rows/columns of the geodesic distance matrix of a graph.
- Betweenness: Loosely, the number of geodesic paths that pass through a node. The number of "times" that any node needs a given node to reach any node by the shortest path.

Hanneman & Riddle (2005) consider that degree centrality can be understood as showing that actors with many ties (at the centre of a network) and actors at the periphery of a network (few ties) have patterns of behaviour that are more constrained and predictable. Actors with only some ties can vary more in their behaviour, depending on to whom they are connected. For example, with out-degree centrality, it is usually a measure of how influential the actor may be.

But degree centrality only takes into account the immediate ties that an actor has, or the ties of the actor's neighbours, rather than indirect ties to all others. Closeness centrality approaches differ, as these approaches emphasize the distance of an actor to all others in the network (Hanneman & Riddle 2005).

The betweenness centrality measurement is that actors who are "between" other actors, and on whom other actors must depend to conduct exchanges, will be able to translate this broker role into power (Hanneman & Riddle 2005). *Flow- betweenness centrality* will be adopted in this research.

The analysis of centralities explains the sources and distribution of power in a network. The network perspective suggests that the power of individual actors is not an individual attribute, but arises from their relations with others. The degree of inequality or concentration of power in a population may be indexed (Hanneman & Riddle 2005).

## **Density analysis**

*Density* represents the connectedness between all actors in a network. It explains a network cohesive attribute as a whole. The density of a network may give us insights into such phenomena as the speed at which information diffuses among the nodes, and the extent to which actors have high levels of social capital and/or social constraint (Hanneman & Riddle 2005).

### **5.3.3 Structural construction and measurements analysis**

According to the research objectives, there is a virtual knowledge supporting network

in construction project process. This virtual knowledge supporting network is based on informal relationships including trust, commitment and proximities in working environment. This network supports knowledge flow and contribution, and drives the process of solution creation and exchange in the design change period.

Data is to be collected and the following measurements are to provide explanation of the network attributes:

*Centrality*: the extent to which a network is organised around one or more central people. In this research, degree centrality, closeness centrality and flow betweenness centrality is to be measured

1. *Degree centrality*: this measurement provides the number of direct ties an actor has in a network; Hanneman & Riddle (2005) explain degree centrality measurement as:

*Actors who have more ties to other actors may be in advantaged positions. Because they have many ties, they may have alternative ways to satisfy needs, and hence are less dependent on other individuals. Because they have many ties, they may have access to, and be able to call on more of the resources of the network as a whole. Because they have many ties, they are often third-parties and deal makers in exchanges among others, and are able to benefit from this brokerage. So, a very simple, but often very effective measure of an actor's centrality and power potential is their degree.*

With directed data, however, it can be important to distinguish centrality based on *in-degree* from centrality based on *out-degree*. If an actor receives many ties, they are often said to be prominent, or to have high prestige. That is, many other actors seek to direct ties to them, and this may indicate their importance. Actors who have unusually high *out-degree* are actors who are able to exchange with many others, or make many

others aware of their views. Actors who display high *out-degree* centrality are often said to be influential actors.

In this research, degree centrality identifies the actor's direct influential power and direct communication frequency with other actors. If all actors have similar degree centrality, that means all actors have similar direct ties to all others and the structure is more flat, which indicates a collaborative working environment. In-degree and out degree measurements are both to be adopted here.

2. *Closeness centrality*: this takes into account all direct and indirect ties in network structure. Closeness centrality emphasizes the distance of an actor to all others in the network by focusing on the geodesic distance from each actor to all others. The sum of the geodesic distance for each actor is the 'farness' of the actor from all others. Actors who are able to reach other actors at shorter path lengths, or who are more reachable by other actors at shorter path lengths have favored positions (Hanneman & Riddle, 2005). In this research, this measurement will be used to explain how close all actors are.
3. *Flow-betweenness centrality*: In reality, people are seeking information sharing and problem solving not just by direct ties (measured by degree), and not only by interacting through geodesic distance (measured by closeness), but also via all other paths. Betweenness centrality is measured by the proportion of the entire flow between two actors, which indicates the strength of team building and information sharing among all actors.

*Density*: The density of a network may give us insights into such phenomena as the speed at which information diffuses among the nodes, and the extent to which actors have high levels of social capital and/or social constraint (Hanneman & Riddle, 2005). This concept provides a measurement to describe a network as a whole for its

cohesion. This research proposes that the density of a network is positively linked to knowledge contribution and integration process.

*Core/periphery measurement:* The core-periphery structure is an ideal typical pattern that divides both the rows and the columns into two classes. The core is a high-density block; the other block, the periphery is a low-density block. Actors in the core are able to coordinate their actions; those in the periphery are not. As a consequence, actors in the core are at a structural advantage in exchange relations with actors in the periphery. The core/periphery patterns in two procurement systems will present the different social network connections in the needs of knowledge supporting activities.

## **5.4 Data collection and processing**

This section provides a statement of detailed data collection developed from previous sections and measurements. There are three parts in this section which answer three questions:

1. What is to be collected, and what kind of cases will meet the study criteria?
2. When to collect data for the study? The timing of data collection is important, the reasons for which are to be stated below.
3. How to collect data, which involves questionnaire design and then network construction

As stated in the previous section, this research adopts design change as an experimental study point; for research purpose, it is important to take a period of time in which the activities involved with this research happen intensively. In design change process, supporting and communication activities take place intensively which involves knowledge contribution and integration in all participants.

## What to collect: Case study criteria and profile

As this research is to compare knowledge supporting activities in competitive/collaborative working procurement systems, projects with different procurement systems are necessary for the comparisons. The pilot study used in this research had a collaborative working procurement system, of the other four cases, two used collaborative working and the other two used competitive working procurement system. The four main case studies construct the comparisons from different Social Network Analysis measurements in two working conditions. The following table presents the general profile of cases used in this research.

Projects	Names	Procurement system	Location	Costs
Pilot study	The Boat House	Collaborative working	North Tyneside	60,7000pounds
Case study 1	The Smoke Houses	Collaborative working	North Tyneside	60,6998pounds
Case study 2	Majestic Bingo Hall	Collaborative working	County Durham	1,900,000pounds
Case study 3	Cleveland and Henry	Competitive working	Middleborough	2,200,000 pounds
Case study 4	Gresley Court	Competitive working	Saltburn by the sea	437,882 pounds

*Table 5.3 cases profile*

For detailed project profiles please refer each individual chapters for case studies.

## When to collect: Timing of project approaching

This research collects data shortly after the completion of the project rather than following a design change from the beginning or in the middle of the change. It is hard to spot a suitable case for this research in an on-going project, as this research focuses on the variation process in a project; sometimes changes are worked out in a short time; sometimes one change leads to a series of changes which takes a long time. Thus data is to be collected by participants recalling. The reasons are:

1. Time consumption. Contacting diary in project process is considered at the beginning for data collection but is rejected later. Most managers are busy with their own daily business and it is pretty common that they “forget” to record some of their activities, or they may have different perceptions of what should be recorded. The researcher of this study is not able to record all necessary data alone as it involves several participants at the same time. Therefore, a questionnaire is designed to collect relational data after change completion, so managers can arrange their time and talk freely.
2. Interest consideration. In the process of design change, some managers/employees are reluctant to reveal information because it is part of negotiation strategy. For example, one party may makes claim against another party but his real purpose may be just to apply some pressure in order to find a good solution for both parties.
3. Changing situation. Sometimes people found it hard to figure out what the relationships are in the project process due to dynamic interactions, only after finishing, could they review and conclude calmly, some unpleasant experience maybe sorted out later
4. Emphasis on data quality rather than quantity. For this research, quantifying relational data cannot be done by counting daily contacts. The real purpose is to determine the relationship between participants, especially supporting and commitment relationships, one may not call another frequently but they still support each other at critical times.
5. Intensive emotional influences. Project process may involve intense emotional actions in project process and this may influence whose perception of relationship; post-project data could revise this in certain situations.
6. Time constraint. Some design changes may last more than 1 year from the very beginning to the end. It is quite normal that some design changes lead to other sub-changes in projects, and it is hard to spot a suitable case in design changing process for this research; collection-after-completion is a better choice for this consideration.

## **How to collect: Data collection method**

Following the research strategy and methods, the data collection procedure is designed to construct a virtual knowledge network based on knowledge supporting activities. This procedure was designed to collect data for social network measurements developed in the previous section, and to construct a network which is built on informal working relationships rather than contractual relationships.

The Social Network data collection in this research is composed of two steps. The first step is to approach key Senior Management informants and ask them to provide an overall overview about a large number and variety of the projects they were involved with. Open discussion was used at this stage in order to obtain the following information:

- Identify suitable cases
- Collect background information on case study projects
- Compose the lists of participants for every project in order to move to the second stage.

For this second stage, data was mainly collected from open discussion, (meetings were recorded by voice recorder) and from completed recording form. The following is a snapshot of a blank version of the recording form:



### Data collection meeting record form

Meeting description			
Date		Time	
Location			
Participants:			
name/position/organization			
name/position/organization			
name/position/organization			
name/position/organization			
name/position/organization			
Notes			
Meeting record			

*Figure 5.2 data collection meeting record form*

The original, as well as a sample of the completed versions of the form are attached in Appendix C.

Once the list of participants in every project was produced (from the first stage), participants involved in these projects were asked to identify any other participants with whom they have “connections” and “ties” (in terms of knowledge supporting relationships). The lists were compiled using interactive forms and the identification of these connections was done simply by ticking the relevant people.

To start with, an approach which collected data from an open discussion with project participants was considered. But later it was considered not suitable, for the following reasons

- **Standardisation.** Every list includes all participants of every projects, the result can be presented in a standardised matrix used for Social Network Analysis
- **Simplification.** By providing the whole list of all participants of every project, people can identify the other people they have “connections” and “ties” (knowledge supporting activities) by clicking on their names. This is considered very important as informants may fail to provide accurate information by participating complicated procedure.

Please refer to Appendix B for a sample of the data collection form from the second stage.

## **5.5 Limitations of the research**

Case study research forms the core of this research study. Although the case study method has many advantages, there are also criticisms.

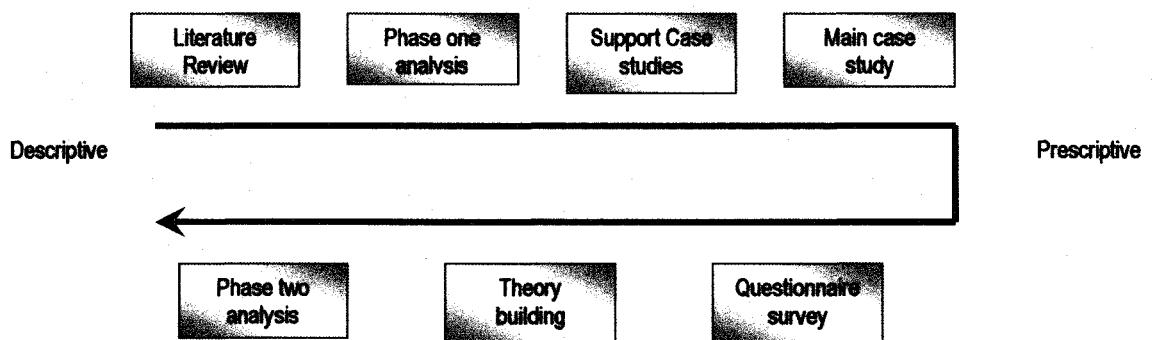
One criticism of the case study method is that it suffers from a lack of rigour and an excess of bias. The dangers of ad hoc theorising and of neglecting to test data are great. The use of "subjective" judgements during the data collection stages can render constructs invalid. According to Bromley (1986), researcher bias has an impact on the internal validity of the data. Becker (1986) agrees, suggesting that researchers may have "feelings" for the subjects and that conclusions that are drawn suffer from a lack of reliability. External validity is also difficult to measure (Berger, 1983). It is difficult to generalise findings to different settings as phenomenon and context are necessarily dependent.

Perhaps the most critical aspect of the case study approach is that it provides only a limited basis for the traditional "scientific generalisation" (Yin, 1994; Remenyi *et al.*,

1998). Notwithstanding, like all experimental observations, case study results can be generalised to theoretical propositions (analytical generalisation) but not to populations or universes (statistical generalisation). Thus, the aim of case studies cannot be to infer global findings from a sample to a population, but rather to understand and articulate patterns and linkages of theoretical importance. It is important to emphasise that case studies deal with unique situations and, because of that, it is not possible to elaborate detailed and direct comparisons of data.

## Summary

The discussion in the second section concluded that this research is a combination of positivism and interpretivism in its aims and objectives, the following figure illustrates the research development.



*Figure 5.2 Research strategy*

(Developed from Pacitti, 1998)

The first stage of research is the literature review phase, aimed at identifying potential research topics. Although this is the beginning of the research, it is a continuous

process throughout the research process.

The pilot study was conducted to uncover the feasibility of the constructs identified in the literature review and to more fully understand the context within which the research takes place.

From the pilot study and literature review the research objectives and case study strategy were developed. The qualitative fieldwork consisted of multiple case studies. The analysis of the qualitative data was conducted in two stages: the first stage uncovered the Knowledge Management used by the case study organisations. The second stage consisted of the analysis of the qualitative data-using proposition forming techniques, and of the quantitative data using statistical techniques. The stages of the research outlined in this study present a methodology which embraces both prescriptive and descriptive research. The literature phase of the research marked the beginning of the descriptive research. As the case studies progress and the knowledge flows between organizations emerge from the initial analyses, there was a definite move along the descriptive-prescriptive spectrum. The second phase of the analysis involved an iterative investigation of qualitative and quantitative data, which encompassed the theory building process. Hence, the output of the research will finish where it began, at the descriptive end of the spectrum.

# **Chapter 6 Pilot study, The “Boat House” project**

## **6.1 Case selection**

This pilot study is carried out after the literature review and methodology discussions in relation to the research aims. After the literature review, research questions are identified as arising from gaps in the literature, and methods and methodology are discussed in order to design the suitable approach to collect valid data for analysis. The Boat House project in North Tyneside was considered suitable for pilot study. The purpose of a pilot study is to “learn from any mistakes, fine tune the approach, and then do it a few more times on other projects” (Greenwood, 2006).

First of all, the Partnering Support Officer at North Tyneside Council, the project client, was approached. After a meeting to explain this research, two cases were selected for study: The Boat House, as pilot study and The Smoke Houses project, as another case study presented later. Both projects are located in the Fish Quay area in North Tyneside, England, UK.

The Fish Quay area has remained a favourite day-trip location for many people in the North East, particularly those who wish to sample fresh fish or fish and chips whilst watching ships pass on the River Tyne. The evolution of the Fish Quay Festival has helped to maintain the place as a known destination. As much of the area lay in a state of dereliction, under-occupancy and disrepair, with public buildings inadequately maintained, a regeneration of this area was undertaken to increase the indigenous business base (North Tyneside Council, 2005).

North Tyneside Council has a Strategic Agreement in place which delivers the Capital and Planned Maintenance programmes for the Council, and the North Tyneside Partnering Agreement (NTPA) route is adopted as a suitable delivery vehicle for these projects.

The NTPA was originally established in 2000 and has now developed into its second phase. The Construction Group is one of three partnering contractors selected following EU Procurement Guidelines. According to North Tyneside Council, strategic partnering procurement allows the whole project team, Client, End-user, Designers and Contractor to work together to produce a building that is most consistent with the objectives of the Client and End-user requirements. The Best Value principle of full consultation with representatives of the user groups is addressed by having end user representation throughout the process. The partnering ethos within the team approach enables all risks to be identified and managed as a team through every stage of the process until a successful completion is achieved. Sir Michael Latham considers the NTPA is “a good example of what can be achieved” in local authorities partnering (North Tyneside Council, 2005), following calls for changes to collaborative working in construction industry. Over three years and 50 projects worth 80million pounds, the NTPA has achieved:

- Better relationships—no litigation or claims
- High levels of client and user satisfaction
- Better time performance—with one project finishing a full year ahead of schedule
- Better value—with average 25% cost saving on the trades engaged on a strategic basis
- Better projects—by engaging in the Supply Chain (North Tyneside Council, 2005)

Therefore, two projects adopting collaborative working from North Tyneside Council are considered suitable for this research. The Boat House project, which is to be

renovated with value of £ 60,7000 for the provision of an art and exhibition area, was selected as a pilot study.

## **6.2 Research data collection**

Before formalising the questionnaire and the data collection approach, there were four meetings with North Tyneside Council Partnering Support, Design Agency, the Partnering Contractor and North Tyneside Development Directorate. The project is discussed from different viewpoints with free expression of participants' opinions.

As stated before, this study adopts whole-network study rather than ego-centred network; a difficult problem for whole-network studies is to decide on the set(s) of objects that lie within a network (Marsden, 2005). This study draws the whole network boundary in the process of data collection. According to Marsden (2005), a whole-network study usually compiles a roster of actors before data collection begins. This study compiled the roster of participants before finishing the final questionnaire. A sample questionnaire was presented to key managers in order to explain the data collection process and ask for relevant documentary evidence such as design briefs, meeting records and other correspondence from the project. Marsden (2005) also suggests that there are several response formats to obtain network data for whole-network studies: binary judgments (often termed sociometric choices) about whether respondents have a specified relationship with each actor on the roster, and ordinal ratings of tie strength, or rankings. Binary judgments are least difficult for respondents; ranking tasks are most demanding (Marsden 2005). Hanneman and Mark (2005) also regard that by far the most common approach to scaling (assigning numbers to) relations is to simply distinguish between relations being absent (coded zero), and ties being present (coded one). In practice, binary data is widely used in network analysis (Hanneman and Mark 2005). In this study, the tie strength is ignored

as this study aimed to explore whether or not partnering promote the supportive relationships between project parties; a binary judgment is clear and suitable for data collection and analysis.

Hanneman and Mark (2005) point out that social network boundaries are those imposed or created by the actors themselves. All the members of a classroom, organization, club, neighbourhood, or community can constitute a population. These are naturally occurring clusters, or networks. So, in a sense, social network studies often draw the boundaries around a population that is known, a priori, to be a network (Hanneman and Mark, 2005). After discussion and analysis of interviewees' opinions, the time scale is limited to a variation order process. In processing variation order, it is hypothesised that the parties involved have intensive interactions with different working patterns in collaborative/competitive working procurement systems. Therefore, the social network boundary is set as all parties involved in this variation order in the project, which means the irrelevant parties in variation order are removed for clarification of network presentation.

In the Boat House Project, a wall supposed to be demolished was found to be an original one, and, as the Boat House is within the boundary of the Scheduled Ancient Monument Site, the English Heritage North East Office were informed and the original design was changed to maintain the existing character and architectural details of the building. The original Boat House is a single storey building; after the discussion with English Heritage, it was agreed that the original wall should be retained and the new storey on top of the original one would be supported on a steel structure making the wall non load bearing. According to the design brief, the Boat House redesign utilizes a timber post and beam frame with purlins and cladding. The omission of the previously specified brickwork, up to a height of approximate 5.5m, provides a saving to offset against the extra cost of the frame.

From the information provided by the main contractor, in total 12 companies were



involved to act as subcontractors or suppliers in this project. These included structural steel, glazing systems, platform lift, tiling floors, roofing, demolitions, scaffold, decoration, flooring, suspended ceilings, wall finishes, asbestos analysis and screeding companies. In the variation order, four subcontractors were involved which are structural steel, glazing systems, the roofing company and suspended ceilings company. The network analysis boundary is based on these parties involved and coded as:

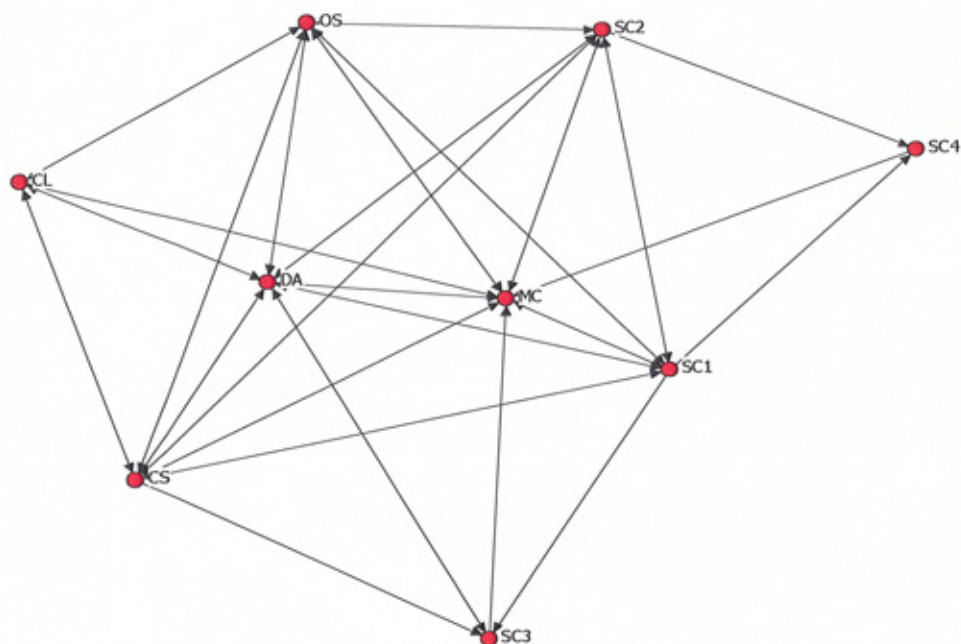
- CL, client
- OS, other stakeholder (English Heritage)
- DA, design agency
- CS, consultant
- MC, main contractor (Construction Group)
- SC1, subcontractor 1 (Structural steel company)
- SC2, subcontractor 2 (Glazing system company)
- SC3, subcontractor 3 (Roofing company)
- SC4, subcontractor 4 (Suspended ceilings)

Though there are small variations in every case, this coding approach will be used in other cases study in order to compare all cases in a standardized formation.

## **6.3 Social Network Analysis**

Visual images can be used to examine the patterning of network data (Freeman, 2005).

To visualise a network as a sociogram, network members are represented as nodes, and the relations between them as lines. In this study, the direction of lines which indicate who are the sender and the receiver of the helping information is ignored, as this study explore the overall “cohesion” and “proximity” in different procurement systems.



*Figure 6.1 Visualisation of knowledge supporting activities in Boat House project*

	CL	CS	DA	OS	MC	SC1	SC2	SC3	SC4
CL	0	1	1	1	1	0	0	0	0
CS	1	0	1	1	1	1	1	1	0
DA	1	1	0	1	1	1	1	1	0
OS	1	1	1	0	1	1	1	0	0
MC	1	1	1	1	0	1	1	0	0
SC1	0	1	1	1	1	0	1	1	1
SC2	0	1	1	1	1	1	0	0	1
SC3	0	0	1	0	1	0	0	0	0
SC4	0	0	0	0	1	0	0	0	0

*Table 6.1 matrix presentation of Boat House project*

There are three main reasons for using "formal" methods in representing social

network data:

1. Matrices and graphs are compact and systematic, they summarise and present a lot of information quickly and easily, and they force us to be systematic and complete in describing patterns of social relations.
2. Matrices and graphs allow us to apply computers to analysing data: This is helpful because doing systematic analysis of social network data can be extremely tedious if the number of actors or number of types of relationships among the actors is large. Most of the work is dull, repetitive, and uninteresting, but requires accuracy.
3. Matrices and graphs have rules and conventions; sometimes these are just rules and conventions that help us communicate clearly, but sometimes the rules and conventions of the language of graphs and mathematics themselves lead us to see things in our data that might not have occurred to us to look for if we had described our data only with words (Hanneman and Mark 2005).

The matrix and sociogram present all knowledge supporting activities in the process of variation between all parties based on dyad relationships. From this sociogram it is clear that all parties are connected, which means all participants involved in the variation process have knowledge supporting connections with other parties, no matter if they are senders or receivers.

### **6.3.1 Centrality analysis**

Everett and Borgatti (2005) suggest that *centrality* is one of the most important and widely used conceptual tools for analysing social network. This development makes it possible to evaluate the relative centrality of different teams or departments within an organisation, or to assess whether a particular ethnic minority in a society is more integrated than another. As mentioned previously, Freeman (1979) categorises

centrality measures into three basic categories—*degree*, *closeness*, and *betweenness*. Everett and Borgatti (2005) conclude that these three measures have come to dominate empirical usage though some other measures of centrality have been proposed. This empirical study uses these three centralities to measure the relationships and positions of all participants involved in projects.

### **6.3.1.1 Degree centrality analysis**

As discussed before, actors who have more ties to other actors may be in advantaged positions. Because they have many ties, they may have alternative ways to satisfy needs, and hence are less dependent on other individuals. Because they have many ties, they may have access to, and be able to call on more of the resources of the network as a whole. Because they have many ties, they are often third-parties and deal makers in exchanges among others, and are able to benefit from this brokerage. So, a very simple, but often very effective measure of an actor's centrality and power potential is their degree (Hanneman and Mark 2005). The ties, or connections, are counted as “degree” in sociogram. The data presented below ignores the direction of ties, which means ignoring who are “senders” and “receivers” in the knowledge supporting activities network, because this project is to explore the collaborative/competitive working patterns in the whole project team, rather than identify the individual organization’s position in the whole network.

### Degree centrality measure of the Boat House Project

	Degree	NrmDegree	Share
MC	8.000	100.000	0.154
CS	7.000	87.500	0.135
DA	7.000	87.500	0.135
SC1	7.000	87.500	0.135
SC2	6.000	75.000	0.115
OS	6.000	75.000	0.115
CL	4.000	50.000	0.077
SC3	4.000	50.000	0.077
SC4	3.000	37.500	0.058

*(NrmDegree= normalized degree, which compares the actual degree to the maximum possible degree)*

### Descriptive statistics

Network Centralization = 35.71%

This network centralization means that the graph centralization is 35.71%. How "centralized" the graphs are as a whole means how unequal of the distribution of centrality are. To explain Freeman's Network Centralization in detail, a star network has to be considered. The star network is the most centralized or most unequal possible network for any number of actors. In the star network, all the actors but one have degree of one, and the "star" has degree of the number of actors, less one. Freeman felt that it would be useful to express the degree of variability in the degrees of actors in our observed network as a percentage of that in a star network of the same size. This is how the Freeman graph centralization measures can be understood: they express the degree of inequality or variance in our network as a percentage of that of a

perfect star network of the same size.

	Degree	NrmDegree	Share
Mean	5.778	72.222	0.111
Sum	52.000	650.000	1.000
Minimum	3.000	37.500	0.058
Maximum	8.000	100.000	0.154

The mean of *degree* is 5.8. On average, actors have a degree of 5.8, which is quite high, given that there are only eight other actors.

Degree centrality as measured in this study is adopted to express frequency and consequently efficiency of collaborative supporting activities between all parties. Organizations with more ties are in an advantageous position because they have more connections. That means they provide (*out degree*) and receive (*in degree*) more knowledge support due to their collaborative relationships with other parties, if a node has many ties normally in a network; he/she is often prominent and enjoys high prestige. That is, many other actors seek to form direct ties with such people, and this indicates their importance. If most nodes have many ties, this network is tightly connected.

### 6.3.1.2 Closeness centrality analysis

*Closeness centrality* approaches emphasize the distance of an actor to all others in the network by focusing on the distance from each actor to all others. Several alternative approaches to measuring "farness" are available in UCINET. The most common is probably the geodesic path distance (Hanneman and Mark 2005). The length of a walk is defined as the number of edges it contains. A walk between two vertices

whose length is as short as any other walk connecting the same pair of vertices is called a *geodesic* (Borgatti, 1997). Here, "farness" is the sum of the lengths of the shortest paths from ego (or to ego) from all other nodes. Alternatively, the reciprocal of this, or "nearness" can be calculated (Hanneman and Mark 2005).

Hanneman and Mark (2005) suggest that as with most other measures, the various approaches to the distance between actors and in the network as a whole provide a menu of choices. No one definition to measuring distance will be the "right" choice for a given purpose. In the following table, Farness is the sum of the distance (by various approaches) from each ego to all others in the network. "Farness" is then transformed into "nearness" as the reciprocal of farness. That is, nearness = one divided by farness. "Nearness" can be further standardized by norming against the minimum possible nearness for a graph of the same size and connection.

#### Closeness Centrality Measures

	Farness	nCloseness
MC	8.000	100.000
CS	9.000	88.889
DA	9.000	88.889
SC1	9.000	88.889
SC2	10.000	80.000
OS	10.000	80.000
CL	12.000	66.667
SC3	12.000	66.667
SC4	13.000	61.538

*(nCloseness= Normalized Closeness. It Is the closeness divided by the minimum possible farness expressed as a percentage)*

## Statistics

	Farness	nCloseness
Mean	10.222	80.171
Std Dev	1.618	12.171
Sum	92.000	721.538
Minimum	8.000	61.538
Maximum	13.000	100.000

Network Centralization = 47.80%

Graph centralization is to calculate a measure of inequality in the distribution of distances across the actors, relative to a pure star network. For the figure of 47.8% means that all distances are relatively equally distributed between all actors. If figure is very high, that means the distances are not equally distributed.

*Closeness centrality* emphasizes the distance of an actor to all others in the network by focusing on the geodesic distance from each actor to all others. The sum of the geodesic distance for each actor is the 'farness' of the actor from all others. Actors who are able to reach other actors at shorter path lengths, or who are more reachable by other actors at shorter path lengths have favored positions (Hanneman and Mark 2005). In this study, closeness centrality is to present how "close" and "direct connected" of all project parties in problem solving with knowledge support. In closely connected project network, problem solving activities seek the shortest path between all members. As the absence of ties decrease between certain members, the transaction costs decrease due to the closeness and proximity. Therefore problem solving in the project process is more effective.



### 6.3.1.3 Flow betweenness centrality analysis

According to Hanneman and Mark (2005), the *betweenness centrality* measure characterizes actors as having positional advantage, or power, to the extent that they fall on the shortest (geodesic) pathway between other pairs of actors. The idea is that actors who are "between" other actors, and on whom other actors must depend to conduct exchanges, will be able to translate this broker role into power. The flow centrality approach expands the notion of betweenness centrality. It assumes that actors will use all pathways that connect them, proportionally to the length of the pathways. Betweenness is measured by the proportion of the entire flow between two actors (that is, through all of the pathways connecting them) that occurs on paths of which a given actor is a part. For each actor, then, the measure adds up how involved that actor is in all of the flows between all other pairs of actors (Hanneman and Mark 2005). Therefore, *flow betweenness centrality* here is to detect overall team working and information flow between all members in project variation process. As the *flow betweenness centrality* increases, the overall team working pattern is more collaborative as there are always alternative ties to bridge two members in the network in case one tie fails to deliver information or favours.

	FlowBet	nFlowBet
CL	3.214	5.740
CS	8.029	14.337
DA	12.195	21.777
OS	5.981	10.680
MC	17.195	30.706
SC1	8.895	15.884
SC2	6.848	12.228
SC3	0.714	1.276
SC4	0.952	1.701

Network Centralization Index = 20.253%

Descriptive statistics for each measure

	FlowBet	nFlowBet
Mean	7.114	12.703
Std Dev	5.022	8.967
Sum	64.024	114.328

The degree of inequality or concentration in the distribution of flow betweenness centralities among the actors is fairly low --relative to that of a pure star network (the network centralization index is 20.3%). This means that all information flow are equally distributed between all units.

### 6.3.2 Core/periphery analysis

As discussed in previous section, the *core-periphery* structure is an ideal typical pattern that divides both the rows and the columns into two classes. The core is a high-density block; the other block the periphery is a low-density block. Actors in the core are able to coordinate their actions; those in the periphery are not. As a consequence, actors in the core are at a structural advantage in exchange relations with actors in the periphery.

Core/Periphery Class Memberships:

1: CL CS DA OS MC SC1 SC2

2: SC3 SC4

Blocked Adjacency Matrix

	CL	CS	DA	OS	MC	SC1	SC2	SC3	SC4
CL		1	1	1	1				
CS	1		1	1	1	1	1	1	
DA	1	1		1	1	1	1	1	
OS	1	1	1		1	1	1		
MC	1	1	1	1		1	1		
SC1		1	1	1	1		1	1	1
SC2		1	1	1	1			1	1
SC3			1		1				
SC4					1				

*Table 6.2 Core/Periphery Class presentation of the Boat House project*

This is an express of another visualization of the whole project network; it is obvious that most units are in core block, only two units are in the periphery block. This means that most units are involved in the centre of knowledge supporting/discussion activities in the variation process.

### 6.3.3 Density analysis

Density (matrix average) = 0.6389

Standard deviation = 0.4803

The density of the information exchange relation matrix is 0.6389. That is 64% of all the possible ties are present. The standard deviation of the entries in the matrix is also given. But for binary data, the standard deviation is largely irrelevant -- as the standard deviation of a binary variable is a function of its mean (Hanneman and Mark2005). Therefore, the standard deviation will not be presented in the following

projects. The density itself here cannot be interpreted in a meaningful way without comparing with projects from different procurement systems.

## **6.4 Key issues in the pilot study**

In order to consider the key issues from the pilot study, the research objectives which lead to measurements selection and analysis are to be reviewed here first.

The aim of this research is to compare knowledge integration in two different working environments: namely, a collaborative environment and a more traditional, competitive one.

In order to achieve this aim, the research work used a Social Network approach. Accordingly, the following objectives were set

- A description of the present application of Social Network Theory, competitive/collaborative working and Knowledge Management in a construction project context.
- A comparison of different social network structures within two different procurement systems, which are competitive and collaborative procurement systems, to what extent and measures these two networks differ. This research proposes that a project with a collaborative partnering relationship would create different networks' structures from a non-partnering one. This will examine that in what measures some social networks attributes vary in different procurement systems. Varied network structure and attributes will be used to explain different knowledge transaction activities in project process. The comparison will display to what extent and under what conditions collaborative working could lead to certain advantages and how to reinforce these issues to support the advantages.

The social structural conditions which supporting collaborative working and knowledge integration will reduce non-collaborative behaviour, while fostering cooperation and support towards others.

- An investigation of knowledge integration features in two procurement systems from a Social Network Analysis perspective. This will be achieved by analysing individual organizations in the measures of centrality and density. This exploration will identify benefits and constraints of Knowledge Management in collaborative working within inter-organizational extent from Social Network Analysis perspective, and to conclude the key business characteristics of Knowledge Management within strategic partners supporting collaborative working in construction projects.
- A description of the role of social networks in terms of knowledge integration in collaborative working. This will be achieved by the following:
  1. Establishment of key knowledge roles in collaborative working partners, to ensure that knowledge reach all the parties of a project that need them.
  2. Mapping existing pathways and patterns for knowledge flow between organisations in collaborative working projects.

From the analysis in section 6.3, it is argued that the measurements have been selected to answer the issues raised in the objectives. The data collection of the knowledge supporting activities shows the knowledge supporting network in the project variation process by matrix and sociogram. The visualization by sociogram is helpful to understand the interactive process of knowledge communication and supporting activities. The other objectives are to be achieved by other case studies which lead to the comparison of two procurement systems and knowledge supporting networks.

Through the pilot study, several key issues are identified and relevant problems raised and these have been resolved in the pilot study process. In summary, this pilot study resolved the following problems.

- To develop detailed data collection methods under the methodology discussed in

chapter 5.

- To refine research questions regarding data collection routine.
  - To select appropriate measurements from Social Network Analysis perspective.
- For instance, in-degree/out-degree measurements are ignored because the directions of ties are ignored. As this study is to explore the overall connections between organizations in project process, the roles of receiver/sender are not concern of this study. Consequently, all directions in closeness centrality and flow betweenness centrality are moved before data analysis. This research didn't take individuals as actors in the network because this study focuses on knowledge supporting activities between *organizations* rather than *individuals*, though these connections are established via individuals. The connections between individuals from different groups are collected to represent connections between organizations. The strength of ties are not considered because this research is to explore the existence of connections by knowledge support, the main concern is "if there are" ties between participants, rather than how the ties developed and how strong the ties are.
- To set the boundary of this knowledge supporting network. At the beginning, the network boundary is set as all parties involved in project process. But visualization of the network shows that there are too many "isolates", which have no connections with other members. Therefore in this pilot study the variation order process was selected as a slice of sample from the overall project process, and the network boundary is set as all members involved in variation order process.
  - To standardize roles involved. In order to compare several networks later after other case studies, all members involved are presented as roles in project process, such as client, main contractor. This will help to clarify network structure and roles.

## Summary

In order to refine the research routine at a practical level, a pilot study was carried out. This pilot study started from informal and unstructured interview discussion with members of staff from North Tyneside Council. These informal meetings and discussions resolved conflicts for the data collection between theoretical planning and collection in practice. Some key issues were concluded for later case studies. Although the pilot study was carried out only on a collaborative working project, the basic routine to analyze and compare both collaborative and competitive working in construction project has been set, which provides a solid foundations for later case studies.

As some quantitative data have been presented in this chapter, such as centrality and density analysis, the basic concepts and reasons for selecting these measurements are considered. But the meaningful interpretation of data can only be concluded after data collection is complete; one single case cannot bring meaningful insight without comparisons with other cases from different procurement systems.

# **Chapter 7 Case study, The “Smoke Houses” project**

## **7.1 Introduction**

The Smoke Houses project is the other case from North Tyneside Council under its strategic partnering agreement. It is one of the key buildings in North Tyneside Regeneration plan in the Fish Quay area. The North Tyneside Regeneration team has the role of oversee development of key buildings. Specific landmark and key opportunity sites were identified for refurbishment and development. The project total value is £ 606998. For the Fish Quay development and North Tyneside Regeneration please refer to Chapter 6.

Early in 2002, North Tyneside Council considers that they should work together with their construction contractor in an open and honest environment dedicated to achieving mutually beneficial solutions with the following partnering aims:

- Clearly identifying and agreeing mutual objectives
- Achieving the objectives with a customer focus
- Establishing continuous and sustainable improvement on a measurable basis
- Having a positive approach to problem solving

North Tyneside Council was determined to cultivate a “no blame” attitude in identifying and dealing with all issues. Also they aimed to be constructively critical in monitoring the performance of all parties. In order to achieve the above aims, North Tyneside council also set the following detailed objectives towards which all parties involved work together. The partnering objectives are

- To enjoy working together;



- To recognise the needs, aims and policies of the client/customer chain throughout all stages of the process;
- To ensure that all communications are appropriate, constructive, comprehensive, timely and open;
- To ensure innovation and transparency within the project processes;
- To appropriately measure and demonstrate continuous improvement in the areas of time, cost, quality, client satisfaction, predictability, business performance, health and safety, reduction in unnecessary paperwork;
- To establish appropriate benchmark standards against which to monitor continuous improvement;
- To utilise methodologies that embrace quantitative and qualitative methods for measuring and demonstrating performance improvement;
- To avoid conflicts but where they arise to resolve them quickly at the lowest possible level;
- To ensure that all involved in the partnering agreement are supported and encouraged by education, training and development;
- To empower people to achieve the above;

They worked out a unique working process under the partnering agreements as described in the following chart



Sir Michael Latham, author of the Latham reports and Chairman of CITB considers that North Tyneside Partnering Agreements is a good example of what can be achieved and highly recommends it to other councils (Greenwood, 2004).

The North Tyneside Council Partnering Agreement is considered as a mature partnering procurement system and the Smoke Houses project under this working scheme is regarded as a suitable project for this research. It is a further example of “collaborative” procurement. According to the main contractor, normally they don’t set strict agenda for every meeting, agenda and matters will be dealt with as they arise.

This project started on site in July 2005 and finished at May 2006. At the original design stage, the development aimed to provide space for a single pre-determined tenant. The original design brief was

- Refurbishment of existing buildings with glazed link to create circulation space and display area;
- Bring back into use the derelict Unit 9, Clifford's Fort, through full refurbishment with a new first floor to create additional lettable floor space;
- Develop and landscape the area between unit 9 and the other Smoke Houses buildings to provide disabled access and means of escape in case of fire;
- Development of design subject to consultation with NTC Planning Authority/Historic Buildings/North East Office English Heritage.

Later, the purpose of this building was changed to office use without pre-determined tenants. The Refined Design Brief was

“Potential for provision of maximum 2no. Office Units with the flexibility to be let as one large Unit subject to integration of additional WC's/kitchen areas to accommodate usage.”

In this Smoke Houses project, the main contractor was Construction Group.

From the information provided by the main contractor, 12 companies were involved acting as subcontractor or supplier in this project. These included structural steel, glazing system, platform lift, tiling floors, roofing, demolitions, scaffold, decoration, flooring, suspended ceilings, wall finishes, asbestos analysis and screeding. The subcontractors involved in the particular variation process examined are: Glazing System, Tiling Flooring, Decoration and Suspended Ceiling. The coding system developed from the pilot study was used here:

- CL, client
- DA, design agency
- CS, consultant
- MC, main contractor (Construction Group)
- SC1, subcontractor 1 (Glazing System)
- SC2, subcontractor 2 (Tiling Flooring)
- SC3, subcontractor 3 (Decoration)
- SC4, subcontractor 4 (Suspended Ceiling)

The following data collection and analysis is based on this coding format.

## **7.2 Social Network Analysis**

As the methods and advantages for data collection have been discussed in detail in the chapters of research design and pilot study, the following sections simply present the collected data with explanations.

In the Smoke Houses project, eight units are involved in the variation process. The knowledge supporting activities are presented both in sociogram and matrix below

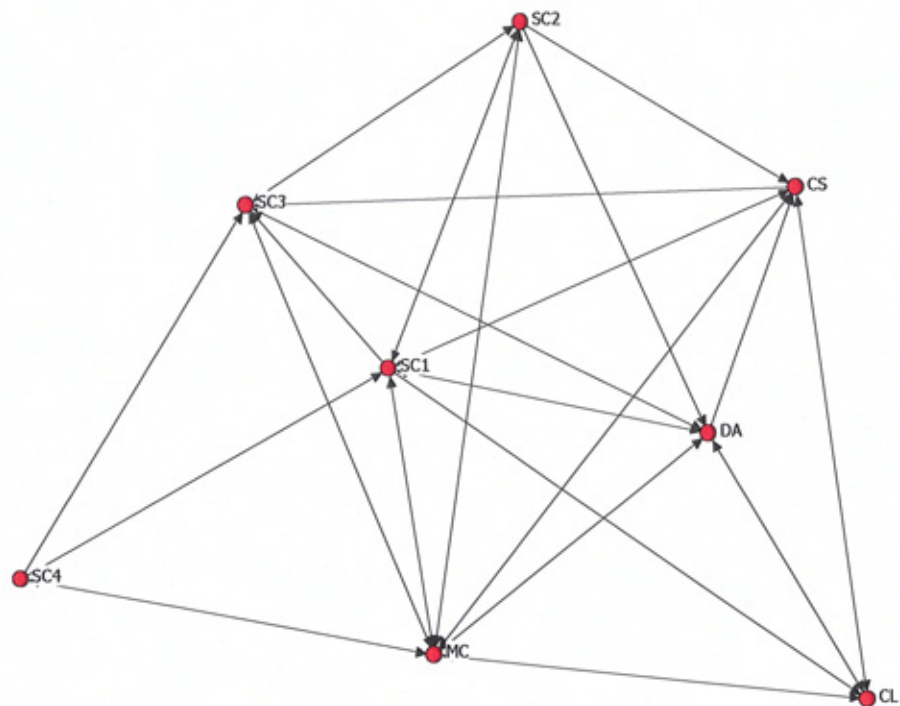


Figure 7.2 Visualization of knowledge supporting activities in Smoke Houses Project.

	CL	CS	DA	MC	SC1	SC2	SC3	SC4
CL	0	1	1	1	0	0	0	0
CS	1	0	0	1	1	0	1	0
DA	1	1	0	1	1	0	1	0
MC	1	1	1	0	1	1	1	1
SC1	1	1	1	1	0	1	1	0
SC2	0	1	1	1	1	0	1	0
SC3	0	0	1	1	0	1	0	0
SC4	0	0	0	1	1	0	1	0

Table 7.1 Visualization of knowledge supporting activities in Smoke House project

From this visualization and matrix, it can be seen that all units in the Smoke Houses

project under Partnering Agreements are tightly connected.

## 7.2.1 Centrality analysis

As discussed in the pilot study and research design chapters, this study adopts three centralities to measure relationships and positions of all participants involved in projects, which are *degree centrality*, *closeness centrality* and *flow betweenness centrality*.

### 7.2.1.1 Degree centrality analysis

Degree centrality measure of the Smoke Houses Project

	Degree	NrmDegree	Share
SC1	7.000	100.000	0.159
MC	7.000	100.000	0.159
DA	6.000	85.714	0.136
CS	6.000	85.714	0.136
SC3	6.000	85.714	0.136
SC2	5.000	71.429	0.114
CL	4.000	57.143	0.091
SC4	3.000	42.857	0.068

**Descriptive statistics:**

	Degree	NrmDegree	Share
Mean	5.500	78.571	0.125
Sum	44.000	628.571	1.000
Minimum	3.000	42.857	0.068
Maximum	7.000	100.000	0.159

Network Centralization = 28.57%

These network centralization means that the graph centralization is 28.57% of these theoretical maximums.

### 7.2.1.2 Closeness centrality analysis

	Farness	nCloseness
SC1	7.000	100.000
MC	7.000	100.000
DA	8.000	87.500
CS	8.000	87.500
SC3	8.000	87.500
SC2	9.000	77.778
CL	10.000	70.000
SC4	11.000	63.636

	Farness	nCloseness
Mean	8.500	84.239
Std Dev	1.323	12.236
Sum	68.000	673.914
Minimum	7.000	63.636
Maximum	11.000	100.000

Network Centralization = 39.03%

*Closeness centrality* emphasizes the distance of an actor to all others in the network by focusing on the geodesic distance from each actor to all others. The sum of the geodesic distance for each actor is the ‘farness’ of the actor from all others. Actors who are able to reach other actors at shorter path lengths, or who are more reachable by other actors at shorter path lengths have favoured positions. In this study, closeness centrality is to present how “close” and “direct connected” of all project parties in problem solving with knowledge support.

### 7.2.1.3 Flow betweenness centrality analysis

	FlowBet	nFlowBet
CL	2.733	6.508
CS	4.767	11.349
DA	5.633	13.413
MC	18.200	43.333
SC1	6.033	14.365
SC2	2.967	7.063
SC3	6.483	15.437
SC4	0.933	2.222



Network Centralization Index = 33.282%

### **Descriptive statistics for each measure**

	FlowBet	nFlowBet
Mean	5.969	14.211
Std Dev	4.953	11.793
Sum	47.750	113.690

Flow betweenness centrality here is to detect team working and information flow between all members in project variation process.

The degree of inequality or concentration in the distribution of flow betweenness centralities among the actors is fairly low (the network centralization index is 33.282%). This means that all information flow are equally distributed between all units.

## **7.2.2 Core/periphery analysis**

Core/Periphery Class Memberships:

- 1: CL CS DA MC SC1 SC2 SC3
- 2: SC4

Blocked Adjacency Matrix

	CL	CS	DA	MC	SC1	SC2	SC3	SC4
CL		1	1	1				
CS	1			1	1		1	
DA	1	1		1	1		1	
MC	1	1	1		1	1	1	1
SC1	1	1	1	1		1	1	
SC2		1	1	1				
SC3			1	1		1		
SC4				1	1		1	

*Table 7.2 Core/Periphery Class presentation of Smoke Houses project*

It is obvious that most parties are tightly connected in the “core” part, only 1 subcontract is listed in the periphery part. This means that most parties in the variation process provide or accept knowledge supporting activities in the collaborative working environment.

### 7.2.3 Density analysis

Density (matrix average) = 0.6429

The density of the information exchange relation matrix is 0.6429. That is 64% of all the possible ties are present. It is above average. The density itself here cannot be interpreted in a meaningful way without comparing with projects from different procurement system.

## Summary

Based on the research plan set out in the pilot study, this chapter continues with a further case study which is a construction project executed under collaborative working conditions. All measurements discussed and adopted in the pilot study are used again to measure network relationships between team members in this project, such as centrality and density analysis.

The sociogram generated from the socio-matrix shows that all participants in the Smoke Houses Project are tightly connected, which is a reflection of a mature partnering procurement system.

The centralities analysis also demonstrates that the collaborative working system promotes further “ties” between working organizations. For example, the means of degree centrality, which is a reflection of direct ties around every individual member, scored 5.5. Thus it can be interpreted that every organization has an average of 5.5 direct connections in the total of 8 teams. This confirms that in collaborative working organizations participants contribute and exchange their knowledge more frequently and directly. Meanwhile, the overall density of the whole network scored 64.43%, more than average (50%), which is a reflection of the collaborative working pattern.

Also in core/periphery analysis, most parties are tightly connected in the “core” part, with only 1 subcontract being listed in the periphery category. From this we can say that most parties in the variation process provide or accept knowledge supporting activities in the collaborative working environment.

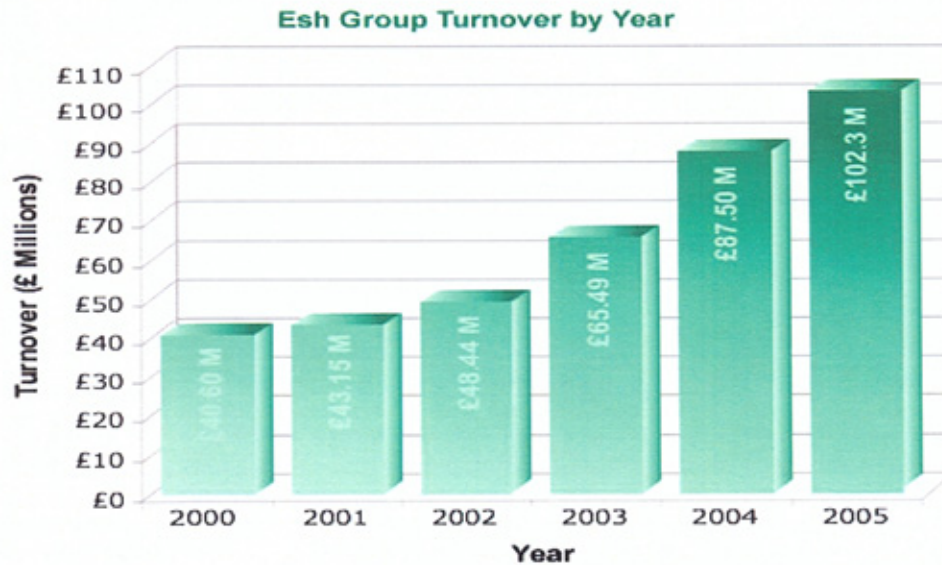
As discussed in the pilot study, the quantitative data presented cannot be interpreted in a meaningful way in a single case study, though these data generate a general description about a single project. The comparisons in Chapter 11 will draw useful

analyses and insight by comparing the measurements of all cases.

# **Chapter 8 Case study, The “Majestic Bingo Hall” project**

## **8.1 Introduction**

The two case studies presented in previous two chapters, including the one for the pilot study, were both from North Tyneside Council. Both two cases adopted a partnering procurement system. That is to say, they fell in the definition of collaborative working adopted for this study. After the two cases from North Tyneside Council, a contractor Esh Group was approached for case studies and data collection for this research project. Founded in the 1970's, Esh Group is the largest indigenous construction group operating in the North East of England. Esh group directly employs nearly 1200 people and their turnover has more than doubled to over £100m in the last five years. All Esh Group companies either hold or are working towards compliance with ISO 9001:2000. And thus all relevant information was well documented and easy access for this research.



*Figure 8.1 Esh group financial overview*

The Majestic Bingo Hall project is located in County Durham. The main aim is the construction of 18 flats 2 town houses and 2 bungalows on a brown field site with total value of 1,900,000pounds. The client, Three Rivers Housing group, is a leading housing provider in the North East of England which was established in 1971. This project started from February 2005 and was completed in October 2006. Everyone involved in this project could recall everything clearly when they were approached for data collection.

The variations involved in this project are 1) Change in roof tile due to planning restriction 2) Re route of drainage due to existing services present 3) increased service utility costs therefore looked at numerous savings for the client to bring costs down to target cost.

The contract used in this project was the PPC 2000 (Project Partnering Contract). PPC 2000 was produced in 2000 as the first Standard Form of Contract for Project Partnering by the Association of Consulting Architects, this contract includes in full detail the required partnering objectives and targets. The parties to the contract may include not only the contractor and employer but others in the partnering team such as

the employer's designers and some of the subcontractors which is in marked contrast from the usual two- party contract. Therefore, this project is considered to measure knowledge supporting activities in collaborative working.

From the information provided by the main contractor the following parties are involved in these variation processes. Therefore, the coding system developed from the pilot study is used here:

- CL, client
- DA, design agency
- QS, quantity surveyor
- MC, main contractor (Dunelm from Esh group )
- SC1, subcontractor 1 (Structural Engineering)
- SC2, subcontractor 2 (Electrical )
- SC3, subcontractor 3 (Decoration)
- SC4, subcontractor 4 (Roofing)

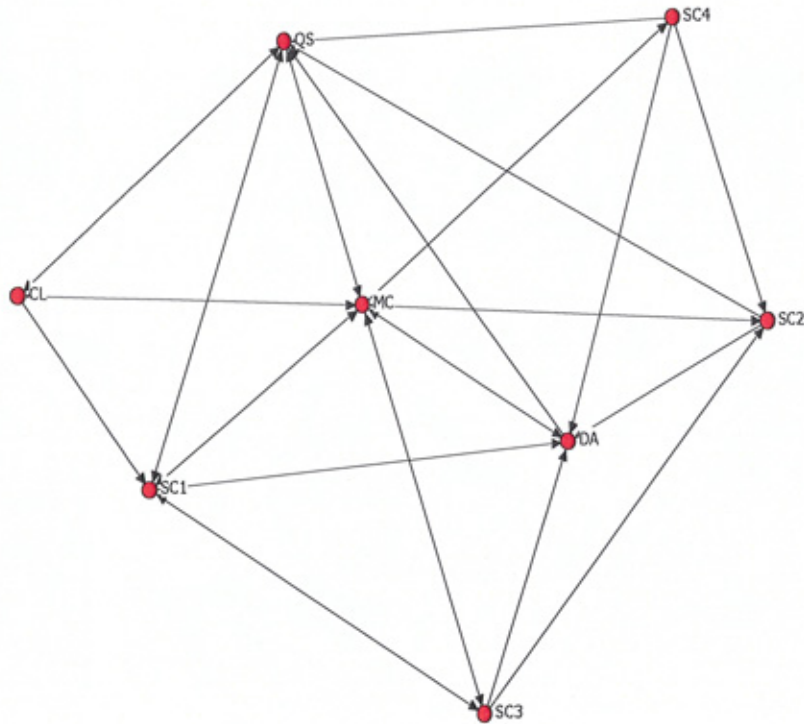
The following data collection and analysis is based on this coding format.

## **8.2 Social Network Analysis**

As before the methods of data collection have been discussed in detail in earlier chapters. Therefore, the following sections simply present the collected data with explanations.

In the Majestic Bingo Hall project, eight units are involved in the variation process. The knowledge supporting activities are presented both in sociogram and matrix below.





*Figure 8.2 Visualization of knowledge supporting activities in Majestic Bingo Hall Project.*

	CL	DA	QS	MC	SC1	SC2	SC3	SC4
CL	0	0	1	1	1	0	0	0
DA	0	0	1	1	0	0	0	0
QS	1	0	0	1	1	0	0	0
MC	1	1	1	0	1	1	1	1
SC1	0	1	1	1	0	0	1	0
SC2	0	1	1	1	0	0	0	0
SC3	0	1	0	1	1	1	0	0
SC4	0	1	1	0	0	1	0	0

*Table 8.1 Matrix presentation of Majestic Bingo Hall project*

From the visualization and matrix, it can be seen that all units in the Majestic Bingo Hall project under Partnering Agreements are tightly connected.



## 8.2.1 Centrality analysis

As already discussed, this study adopts three centralities to measure relationships and positions of all participants involved in projects. These are *degree centrality*, *closeness centrality* and *flow betweenness centrality*.

### 8.2.1.1 Degree centrality analysis

	Degree	NrmDegree	Share
MC	7.000	100.000	0.175
QS	6.000	85.714	0.150
DA	6.000	85.714	0.150
SC1	5.000	71.429	0.125
SC2	5.000	71.429	0.125
SC3	4.000	57.143	0.100
SC4	4.000	57.143	0.100
CL	3.000	42.857	0.075

Descriptive statistics:

	Degree	NrmDegree	Share
Mean	5.000	71.429	0.125
Sum	40.000	571.429	1.000
Minimum	3.000	42.857	0.075
Maximum	7.000	100.000	0.175

Network Centralization = 38.10%

These network centralization means that the graph centralization is 38.10% of these theoretical maximums.

### 8.2.1.2 Closeness centrality analysis

	Farness	nCloseness
MC	7.000	100.000
QS	8.000	87.500
DA	8.000	87.500
SC1	9.000	77.778
SC2	9.000	77.778
SC3	10.000	70.000
SC4	10.000	70.000
CL	11.000	63.636

	Farness	nCloseness
Mean	9.000	79.274
Std Dev	1.225	11.101
Sum	72.000	634.192
Minimum	7.000	63.636
Maximum	11.000	100.000

Network Centralization = 51.32%

Graph centralization is used to calculate a measure of inequality in the distribution of

distances across the actors, relative to a pure star network. For the figure of 51.32% means that all distances are relatively equally distributed between all actors. If figure is very high, that means the distances are not equally distributed.

Closeness centrality emphasizes the distance of an actor from to all others in the network by focusing on the geodesic distance from each actor to all others. The sum of the geodesic distance for each actor is the ‘farness’ of the actor from all others. Actors who are able to reach other actors at shorter path lengths, or who are more reachable by other actors at shorter path lengths have favored positions. In this study, closeness centrality is to present how “close” and “direct connected” of all project parties in problem solving with knowledge support.

### 8.2.1.3 Flow betweenness centrality analysis

	FlowBet	nFlowBet
CL	2.267	5.397
DA	6.833	16.270
QS	8.833	21.032
MC	10.833	25.794
SC1	7.500	17.857
SC2	5.500	13.095
SC3	3.467	8.254
SC4	2.600	6.190

Network Centralization Index = 13.209%

#### Descriptive statistics for each measure

	FlowBet	nFlowBet
Mean	5.979	14.236
Std Dev	2.883	6.864
Sum	47.833	113.889

Flow betweenness centrality here is to detect team working and information flow between all members in project variation process.

The degree of inequality or concentration in the distribution of *flow betweenness centralities* among the actors is fairly low (the network centralization index is 13.209%. This means that all information flow are equally distributed between all units.

## 8.2.2 Core/periphery analysis

Core/Periphery Class Memberships:

- 1: CL DA QS MC SC1 SC2 SC3
- 2: SC4

Blocked Adjacency Matrix

	CL	DA	QS	MC	SC1	SC2	SC3	SC4
CL			1	1	1			
DA			1	1				
QS	1			1	1			
MC	1	1	1		1	1	1	1
SC1		1	1	1			1	
SC2		1	1	1				
SC3		1	1	1	1	1		
SC4		1	1		1	1		

*Table 8.2 Core/Periphery Class presentation of project Majestic Bingo Hall*

It is very obvious that most parties are tightly connected in the “core” part, only two subcontracts are listed in periphery part. It means that most parties in the variation process provide or accept knowledge supporting activities in the collaborative working environment.

### 8.2.3 Density analysis

Density (matrix average) = 0.5179

The density of the information exchange relation matrix is 0.5179. That is 52% of all the possible ties are present. It is above average. The density itself here cannot be interpreted in a meaningful way without comparing with projects from different procurement systems.

## Summary

Based upon the research routine set out previously, this chapter presents a second case study, which is (like Case 1) a construction project under collaborative working conditions.

Though the project in this chapter also adopted the partnering procurement system, it is slightly different from the one in the previous chapter (the “Smoke Houses” project, which was constructed under overall strategic partnering agreements from the public sector). The “Majestic Bingo Hall” project was executed using a project partnering approach applied to the private sector. The final comparison between all cases in Chapter 11 will schedule the differences.

All measurements discussed and adopted in the pilot study (such as centrality and density analysis) were used to measure network relationships between team members in this project..

The sociogram as well as the relationship matrix shows that all organizations involved in the “Majestic Bingo Hall” project are closely connected, which reflects the collaborative working patterns used during the construction process. The average direct connections between the eight organizations is 5, which means that most organizations would find knowledge support directly from the other organizations involved in the variation process. The density of the whole network constructed by the eight organizations is 51.79%, slightly higher than the average. The significant differences will be presented when comparing the results with those from the examination of competitive working.

Similar to the previous case study in the core/periphery analysis, only 1 organization is classified in the periphery category, which also confirmed that most organizations are strongly connected to construct a “core” relationship.

So far two case studies have been described, and these had both adopted a partnering procurement approach. In other words, they have been adopted in this research to present working patterns under collaborative working conditions. The following two chapters present a further two case studies relating to projects executed under competitive working conditions. This will allow the comparison of the different analyses and allow the formulation of conclusions.

# **Chapter 9 Case study, The “Cleveland and Henry” project**

## **9.1 Introduction**

The previous cases, presented in Chapter 6 to 8 were used to measure the knowledge supporting activities in collaborative working environments. In order to compare knowledge supporting activities between collaborative working and competitive working environments, another two cases are presented for comparison, both of which measured knowledge supporting activities in competitive working environment.

The Cleveland and Henry project is located in Middleborough. The main aim of this project is to convert a total of 18 dwellings with total value of £ 2,200,000. The client, Tees Valley Housing Group, is a leading provider of quality homes in the social housing sector in North East England. This project started in February 2006 and lasted 4 months. Everyone involved in this project could recall everything clearly when they were approached for data collection.

The variations examined in this project were 1) Survey existing drainage 2) Carry out expenditure of a provisional item. 3) Electrical systems correction in the properties.

The contract used in this project was the JCT Standard Form (Private with Quantities). The Joint Contracts Tribunal (JCT) was established in 1931. It consisted of the Royal Institute of British Architects (RIBA) and the National Federation of Building Trades Employers (NFBTE). The common purpose was to publish and where necessary amend a standard form of building contract. The JCT published important new editions of the form in 1939, 1963, 1980, 1998 and 2005. From its beginnings JCT



has expanded the number of contributing organisations. In 1998 JCT became a limited company and developed Suite of Standard Forms.

This composes a group of all the mutually consistent documents necessary to operate a particular method of procurement and produced to enable them to be used together, including the following where applicable:

- consultant agreements
- a main contract between the employer and the main contractor;
- sub-contracts between the main contractor and its sub-contractors (both for sub-contractors selected by the employer and for other sub-contractors);
- a standard form of sub-sub-contract between a sub-contractor and such sub-contractor's sub-sub-contractors;
- a design agreement between an employer and a specialist designer;
- forms of tender for issue by an employer to prospective main contractors and for issue by a main contractor to prospective sub-contractors and for issue by a sub-contractor to prospective sub-sub-contractors;
- a form of contract for the supply of goods;
- forms of bond (including performance bonds) and collateral warranties.

JCT substantially revised and rewrote the 1998 family of forms listed below

- Main Contracts
- The Standard Form of Building Contract (JCT 98) in the following variants
- Local Authorities edition with quantities
- Local Authorities edition without quantities
- Local Authorities edition with approximate quantities
- Private edition with quantities
- Private edition without quantities
- Private edition with approximate quantities

There is also a Contractor's Designed Portion Supplement (CDPS)

- Major Project Form (MPF 03)
- Intermediate Form of Building Contract (IFC 98)
- Standard Form of Building Contract With Contractors Design (WCD 98)
- Management Contract (MC 98)
- Minor Works Agreement (MW 98)
- Prime Cost Contract (PCC98)
- Measured Term Contract (MTC 98)
- Jobbing Agreement (JA 90). This consists of the tender JA/T and the agreement conditions JA/C
- Agreement for Housing grant Works (HG(A))
- Building Contract for Home Owner/Occupier (where client deals directly with the builder)(HO/C)
- Building Contract for Home Owner/Occupier (who has appointed a consultant)(HO/RM)
- Contract for Home Repairs and Maintenance (HO/RM)
- Construction Management Documentation

As discussed above, this project adopted JCT Standard Form (Private with Quantities) for Design and Build procurement system. Hence, this project is considered to measure knowledge supporting activities in competitive working environment.

From the information provided by the main contractor the following parties are involved in variation process. Therefore, the coding system developed from the pilot study is used here:

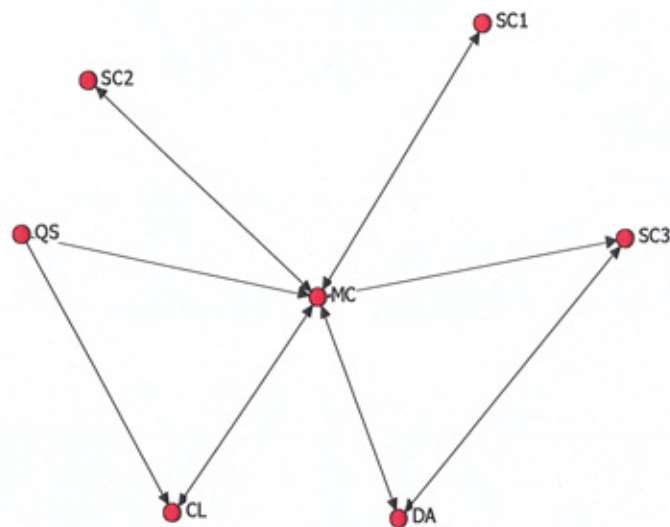
- CL, client
- DA, design agency
- QS, quantity surveyor
- MC, main contractor (Dunelm from Esh group )
- SC1, subcontractor 1 (Structural Engineering)
- SC2, subcontractor 2 (Electrical)

- SC3, subcontractor 3 (Decoration)

The following data collection and analysis is based on this coding format.

## 9.2 Social Network Analysis

In the Cleveland and Henry project, seven units are involved in the variation processes studied. The knowledge supporting activities are presented both in sociogram and matrix below



*Figure 9.1 Visualization of knowledge supporting activities in Cleveland and Henry project*

	CL	DA	QS	MC	SC1	SC2	SC3
--	----	----	----	----	-----	-----	-----

CL	0	0	0	1	0	0	0
DA	0	0	0	1	0	0	1
QS	1	0	0	1	0	0	0
MC	1	1	0	0	1	1	1
SC1	0	0	0	1	0	0	0
SC2	0	0	0	1	0	0	0
SC3	0	1	0	1	0	0	0

*Table 9.1 Matrix presentation of Cleveland and Henry project*

From the visualization and matrix, it can be seen that all units in the Cleveland and Henry project are loosely connected. This is the first visual impression of the supporting relationships in competitive environments. Most units have just 1 or 2 connections to other units.

## 9.2.1 Centrality analysis

As discussed in pilot study and research design chapters, this study adopts three centralities to measure relationships and positions of all participants involved in projects, which are *degree centrality*, *closeness centrality* and *flow betweenness centrality*.

### 9.2.1.1 Degree centrality analysis

Degree

NrmDegree

Share

MC	6.000	100.000	0.375
QS	2.000	33.333	0.125
DA	2.000	33.333	0.125
SC1	1.000	16.667	0.063
SC2	1.000	16.667	0.063
SC3	2.000	33.333	0.125
CL	2.000	33.333	0.125

Descriptive statistics:

	Degree	NrmDegree	Share
Mean	2.286	38.095	0.143
Sum	16.000	266.667	1.000
Minimum	1.000	16.667	0.063
Maximum	6.000	100.000	0.375

Network Centralization = 86.67%

The *network centralization* means that the graph centralization is 86.67% of these theoretical maximums. According to the theory regarding network centralization which is explained in Chapter 6, Network Centralization = 86.67% means that the knowledge supporting activities are highly centred in 1 or 2 members in the variation process; it is more like a star network.

### 9.2.1.2 Closeness centrality analysis

Farness

nCloseness

MC	6.000	100.000
QS	10.000	60.000
DA	10.000	60.000
SC1	11.000	54.545
SC2	11.000	54.545
SC3	10.000	60.000
CL	10.000	60.000

	Farness	nCloseness
Mean	9.714	64.156
Std Dev	1.578	14.826
Sum	68.000	449.091
Minimum	6.000	54.545
Maximum	11.000	100.000

Network Centralization = 92.00%

*Graph centralization* is to calculate a measure of inequality in the distribution of distances across the actors, relative to a pure star network. For the figure of 92% means that all distances are unequally distributed between all actors because the figure is very high, that means the distances are not equally distributed.

*Closeness centrality* emphasizes the distance of an actor to all others in the network by focusing on the geodesic distance from each actor to all others. The sum of the geodesic distance for each actor is the 'farness' of the actor from all others. Actors who are able to reach other actors at shorter path lengths, or who are more reachable by other actors at shorter path lengths have favoured positions. In this study, closeness centrality is to present how "close" and "direct connected" the project parties are in terms of problem solving with knowledge support.

### 9.2.1.3 Flow betweenness centrality analysis

	FlowBet	nFlowBet
CL	3.000	10.000
DA	3.000	10.000
QS	3.000	10.000
MC	28.000	93.333
SC1	0.000	0.000
SC2	0.000	0.000
SC3	3.000	10.000

Network Centralization Index = 86.667%

#### Descriptive statistics for each measure

	FlowBet	nFlowBet
Mean	5.714	19.048
Std Dev	9.192	30.639
Sum	40.000	133.333

*Flow betweenness centrality* here is to detect team working and information flow between all members in the project variation process.

The degree of inequality or concentration in the distribution of flow betweenness centralities among the actors is fairly high (the network centralization index is 86.667%. This means that all supporting information flow are unequally distributed between all units.

### 9.2.2 Core/periphery analysis

Core/Periphery Class Memberships:

1: CL DA MC SC3

2: QS SC1 SC2

Blocked Adjacency Matrix

	CL	DA	MC	SC3	QS	SC1	SC2
CL			1				
DA			1	1			
MC	1	1		1		1	1
SC3		1	1				
QS	1		1				
SC1			1				
SC2			1				

*Table 9.2 Core/Periphery Class presentation of Cleveland and Henry project*

It is very obvious that all parties are scattered into core/periphery parts and they are not well connected. It means that most parties in the variation process don't provide or accept knowledge supporting activities in the competitive working environment.

### 9.2.3 Density analysis

Density (matrix average) = 0.3333



The density of the information exchange relation matrix is 0.3333. That is 34% of all the possible ties are present. It is below average. The density itself here cannot be interpreted in a meaningful way without comparing with projects from different procurement system.

## Summary

Further to the investigation of the previous two case studies (relating to projects executed under collaborative working conditions) the same, using research strategy, set out initially in the pilot study, was employed to explore the network relationships under competitive working conditions.

In the Cleveland and Henry project, the competitive working conditions were encapsulated in the JCT Standard Form of Contract (Private with Quantities).

In this competitive working project, all Social Network Analysis measurements show significant differences from the projects executed under collaborative working. The sociogram and matrix showed that most organizations involved in the variation process are loosely connected. The whole network is like a “star” rather than a “net” presented in collaborative working conditions. The means of degree centrality is 2.286, which can be interpreted that every organization has an average of 2.286 direct connections between the total seven organizations. This is much lower than the projects under collaborative working conditions. Thus under competitive working conditions, we can say that most organizations don’t have direct supports from other organizations in the problem solving process. This can also be confirmed by the network density, which scored 33.33% lower than average.

In the core/periphery analysis, the total of seven organizations were classified into two parts, four in the core category and three in the periphery category, meaning that the core part is not significantly different from the periphery. All organizations, from the core part and periphery part, are loosely connected in knowledge integration for problem solving.

As discussed before, the quantitative data presented cannot be interpreted as statistically significant (given that they are from small numbers of case studies). They do, however, allow us to generate a general description about single projects. The comparisons in Chapter 11 will allow us to produce a useful analysis by comparing the measurements of all cases.

# **Chapter 10 Case study, The “Gresley Court” project**

## **10.1 Introduction**

A further project, the Gresley Court project was selected as another case study under a competitive working environment.

Gresley Court project is located in Saltburn by the Sea. The purpose of this project is to convert 27 flats with total value of £437,882. The client Tees Valley Housing group is a leading housing provider in the North East of England.

The studied variations involved in this project are 1) Change in entrance ramp design/layout

2) A variety of variations in electrical and security systems.

This project adopted JCT Standard Form (Private with Quantities) for Design and Build procurement. Hence, this project is considered to measure knowledge supporting activities in competitive working environment.

From the information provided by the main contractor the following parties are involved in variation process. Therefore, the coding system developed from the pilot study is used here:

- CL, client
- DA, design agency
- QS, quantity surveyor
- MC, main contractor (Dunelm from Esh group )

- SC1, subcontractor 1 (Structural Engineering)
- SC2, subcontractor 2 (Electrical and Security)
- SC3, subcontractor 3 (Decoration)

The following data collection and analysis is based on this coding format.

## 10.2 Social Network Analysis

As the methods and advantages for data collection have been discussed in detail in the chapters of research design and pilot study, the following sections simply present the collected data with explanations.

As listed above, seven units are involved in the variation process in the Gresley Court project. The knowledge supporting activities are presented both in sociogram and matrix below



*Figure 10.1 Visualization of knowledge supporting activities in Gresley Court Project.*

	CL	DA	QS	MC	SC1	SC2	SC3
CL	0	0	0	1	0	0	0
DA	0	0	0	1	0	0	0
QS	1	0	0	1	0	0	0
MC	0	1	0	0	1	1	0
SC1	0	0	0	1	0	0	0
SC2	0	0	0	1	0	0	1
SC3	0	0	0	0	0	0	0

*Table 10.1 Matrix presentation of Gresley Court project*

From this visualization and matrix, it can be seen that all units in the Gresley Court project under JCT contracts are loosely connected. This is the first visualized impression of supporting relationships in competitive environment. Most units have just 1 connection to other units.

### 10.2.1 Centrality analysis

As discussed in earlier chapters, this study adopts three centralities to measure relationships and positions of all participants involved in projects, which are degree centrality, closeness centrality and flow betweenness centrality.

#### 10.2.1.1 Degree centrality analysis

	Degree	NrmDegree	Share
MC	5.000	83.333	0.357
QS	2.000	33.333	0.143
DA	1.000	16.667	0.071
SC1	1.000	16.667	0.071
SC2	2.000	33.333	0.143
SC3	1.000	16.667	0.071
CL	2.000	33.333	0.143

**Descriptive statistics:**

	Degree	NrmDegree	Share
Mean	2.000	33.333	0.143
Sum	14.000	233.333	1.000
Minimum	1.000	16.667	0.071
Maximum	5.000	83.333	0.357

Network Centralization = 70.00%

These network centralization means that the graph centralization is 70.00% of these theoretical maximums. According to the theory regarding network centralization which is explained in Chapter 6, Network Centralization = 70.00% means that the knowledge supporting activities are highly centred in 1 or 2 members in the variation process, it is more like a star network.

### 10.2.1.2 Closeness centrality analysis

	Farness	nCloseness
MC	7.000	85.714
QS	11.000	54.545
DA	12.000	50.000
SC1	11.000	54.545
SC2	10.000	60.000
SC3	15.000	40.000
CL	11.000	54.545

	Farness	nCloseness
Mean	11.143	56.401
Std Dev	2.231	13.256
Sum	78.000	394.805
Minimum	7.000	40.000
Maximum	7.000	40.000

Network Centralization = 75.24%

Graph centralization is to calculate a measure of inequality in the distribution of distances across the actors, relative to a pure star network. For the figure of 75% means that all distances are unequally distributed between all actors because the figure is very high, that means the distances are not equally distributed.

As in this study, closeness centrality is to present how “close” and “direct connected” of all project parties in problem solving with knowledge support, the high percentage of network centralization means that certain units are in significant prestigious position in whole network in seeking knowledge support.

### 10.2.1.3 Flow betweenness centrality analysis

	FlowBet	nFlowBet
CL	1.000	3.333
DA	0.000	0.000
QS	1.000	3.333
MC	27.000	90.000
SC1	0.000	0.000
SC2	10.000	33.333
SC3	0.000	0.000

Network Centralization Index = 83.333%

#### Descriptive statistics for each measure

	FlowBet	nFlowBet
Mean	5.571	18.571
Std Dev	9.363	31.211
Sum	39.000	130.000

Flow betweenness centrality here is to detect team working and information flow between all members in project variation process.

The degree of inequality or concentration in the distribution of flow betweenness centralities among the actors is fairly high (the network centralization index is 83.333%. This means that all supporting information flow are unequally distributed between all units.



### 10.2.2 Core/periphery analysis

Core/Periphery Class Memberships:

1: CL DA QS MC SC1 SC2

2: SC3

Blocked Adjacency Matrix

	CL	DA	QS	MC	SC1	SC2	SC3
CL				1			
DA				1			
QS	1			1			
MC		1			1	1	
SC1				1			1
SC2				1			
SC3							

*Table 10.2 Core/Periphery Class presentation of Gresley Court project*

It is very obvious that all parties are scattered into core/periphery parts and they are not well connected. It means that most parties in the variation process don't provide or accept knowledge supporting activities in the competitive working environment.

### 10.2.3 Density analysis

Density (matrix average) = 0.2381

The density of the information exchange relation matrix is 0.2381. That is 24% of all the possible ties are present. It is below average. The density itself here cannot be interpreted in a meaningful way without comparing with projects from different procurement system.

## Summary

Following a competitive case study in the last chapter, this chapter presents another project under competitive working conditions in order to measure knowledge supporting activities from network relationships.

The Gresley Court project adopted the JCT Standard Form for Design and Build. Under the competitive working conditions, the sociogram and matrix show that most organizations of the total seven organizations have just one connection to others within the whole network. The means of degree centrality shows that every organization has just two direct connections with other organizations on average. Therefore, the whole network is loosely connected in the virtual knowledge supporting network. This is also reflected in the network density which scored 23.81%, which means that only 23.81% of the possible ties are actually presented. Although 6 out of 7 organizations are classified as part of the core category, the connections between the organizations are loose and different from the core category found under collaborative working conditions.

This competitive project is the final case study for the research, In total, four case studies were carried out after the pilot study, two of them were collaborative projects and the other two were competitive ones

The comparisons in Chapter 11 will allow us to produce a useful analysis by

comparing the measurements of all cases

# **Chapter 11 Projects comparisons and analysis**

## **11.1 Introduction**

The purpose of this chapter is to compare the measurements taken between all case studies. In total, four case studies and a pilot study were carried out, two of them were collaborative projects and the other two competitive ones. The first collaborative case study is a collaborative working under strategic partnering agreements, and the second collaborative case study is project partnering. Two competitive working projects adopted JCT Design and Build method. Therefore, the comparisons are divided into two groups, a collaborative group and a competitive group, each group has two cases for comparison. the pilot study was also a collaborative project.

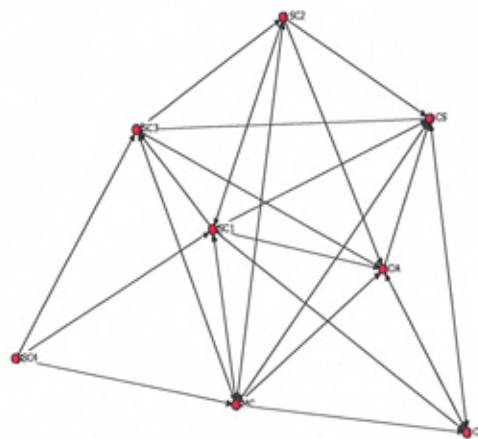
As discussed in pilot study, the data presented in single case study cannot be interpreted in a meaningful way in a single case study, though these data generate a general description about a single project. The comparisons in this chapter are designed to draw meaningful analysis and insight by comparing the measurements of all cases. The comparisons of the data from the Social Network Analysis measurements will lead to qualitative conclusion.

## **11.2 Comparison of cases**

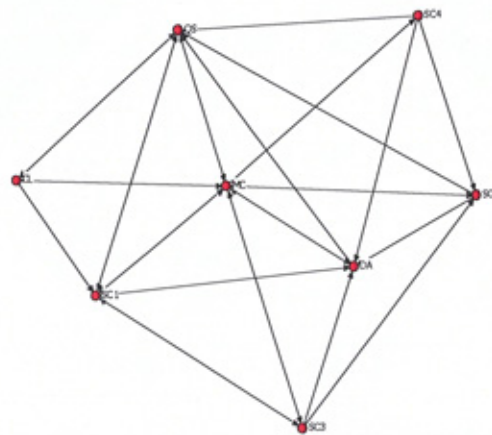
### 11.2.1 Visualized comparison

One of the advantages of Social Network Analysis is that it facilitates visualization of network relationships by sociograms. By comparing the four case studies' sociogram, a straight impression could lead to some understanding knowledge supporting activities both in collaborative working and competitive working.

The followings are examples of two collaborative working project sociograms:



Smoke Houses project

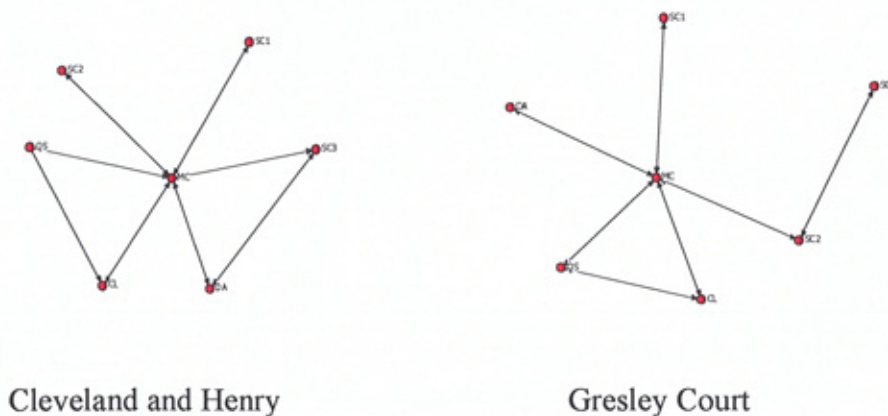


Majestic Bingo Hall project

*Figure 11.1 sociogram comparison of collaborative working projects*

The first is the Smoke Houses project and the second one is the Majestic Hall project. The following two sociograms present two competitive working projects. The first one is the Cleveland and Henry Project and the second one is the Gresley Court project. Both projects used JCT contracts and operated under competitive conditions.





*Figure 11.2 sociogram comparison of competitive working projects*

The first impression of the comparison is that all parties in the two collaborative projects are well connected and the two competitive working projects are more like a “star” network. Most of the possible ties in the two competitive working projects are absent though some did occur. The absent ties lead to structural hole in a network and according to Hanneman and Mark (2005), this result is manifested in high transaction costs.. This could be interpreted as meaning that most parties in collaborative working procurement are contributing more knowledge when other parties involved need support, indeed the parties in strategic partnering arrangement (e.g. the Smoke Houses project) have more connections than in the project-specific partnering project (Majestic Bingo Hall project). Also it is apparent that most parties in competitive working procurement systems are less connected by knowledge supporting activities. Although most parties are connected to the main contractor when problems arise, they have almost no knowledge contributions to each other, other than through the main contractor.

Such visualization is just a simple tool to gain an overall impression before any statistical data are presented and analysed. The following sections are to analyse data from centralities, core/periphery and density aspects.

## 11.2.2 Centralities: comparisons

Before further discussion of centralities comparisons, three basic concepts must be introduced here as they will have effects on understanding some explanations:

- Walk: A walk is a sequence of nodes connected by edges.
- Path: A path is a walk with no repeated nodes.
- Geodesic: This is the shortest path between two nodes.

According to Freeman (1979), centrality is a structural attribute of nodes in a network (not attribute of actors themselves, like income, assertiveness, etc, but of their structural position in the network). It is a measure of the contribution of network position to the importance, influence, prominence of an actor in a network; a measure of an actor's potential for these things based on network position alone. Therefore, the centrality measurement comparisons could show some relationship to different procurement systems from a social network approach.

### 11.2.2.1 Degree centrality: comparisons

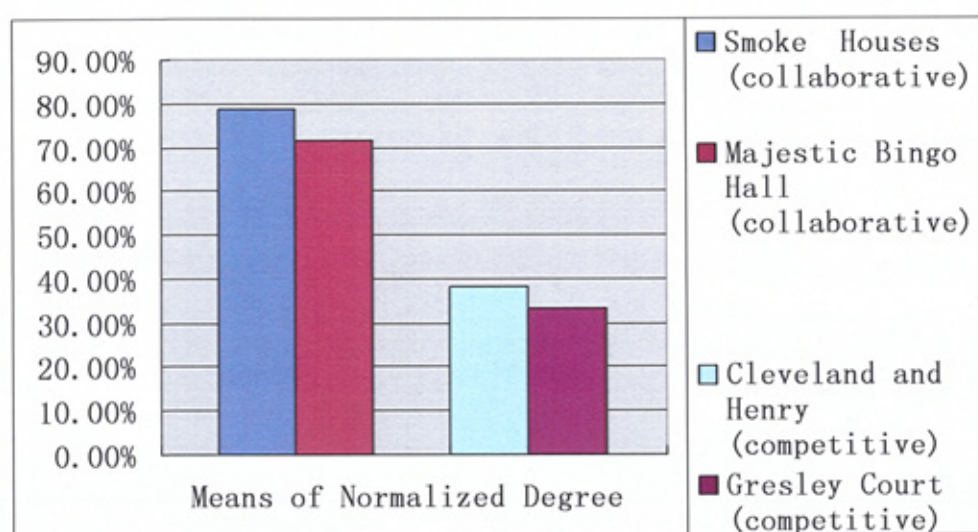
For degree centrality comparison, the means of *Normalized Degrees* and *Network Centralizations* are adopted as comparison measurements.

*Normalized Degree* (nDegree) is the degree divided by the maximum possible degree expressed as a percentage. According to (Freeman, 1979), for *Degree Centrality*, the normalized version divides simple degree by the maximum degree possible, which is usually  $N-1$ , yielding a measure which could be expressed either as a percentage or a value ranging from 0 to 1. In the diffusion of information or “infection”, degree may

translate to probabilities of receiving information or being “infected”.

Projects	Means of Normalized Degree
Smoke Houses (collaborative)	78.57%
Majestic Bingo Hall (collaborative )	71.43%
Cleveland and Henry (completive)	38.10%
Gresley Court (competitive)	33.33%

*Table 11.1 Degree centrality comparison of cases*



*Figure 11.3 Degree centrality comparison of cases*

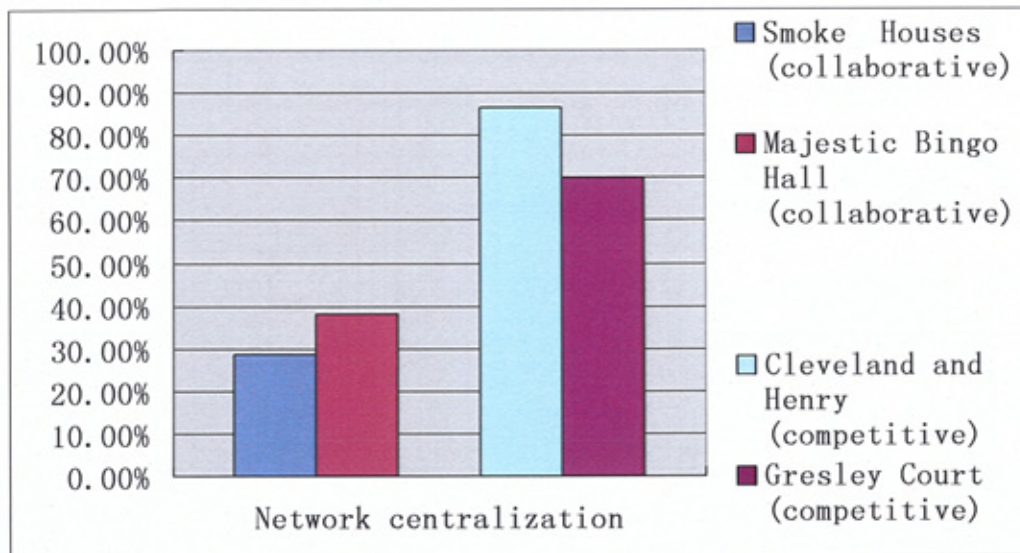
The comparison of *degree means* between the two groups is clear. The first group with two “collaborative projects”, has significantly higher *means* than the two “competitive projects”. In the Social Network Analysis, this could be interpreted to mean that more connections exist in the first collaborative group than those in the second competitive group. Thus, in reality, it could be inferred that more knowledge



supporting activities take place in collaborative projects than competitive ones. The knowledge supporting virtual network in collaborative working projects is more intensively connected than the one in competitive working projects.

Projects	Network centralization
Smoke Houses (collaborative)	28.57%
Majestic Bingo Hall (collaborative)	38.10%
Cleveland and Henry (competitive)	86.67%
Gresley Court (competitive)	70.00%

*Table 11. 2 Degree centralization comparison of cases*



*Figure 11. 4 Degree centralization comparison of cases*

The comparison of *Network Centralization* can be used to map the relationships from another angle. As explained before, *Network Centralization* is used to measure the

overall network as a whole, showing how unequal is the distribution of centrality. The higher *centralization* in competitive projects means that connections happened mainly between several units. In collaborative working projects on the other hand, the knowledge supporting activities happened relatively equally between *all* units. In competitive working, just a few members supported one another by their knowledge and expertise, without any connections with the rest.

### 11.2.2.2 Closeness centrality

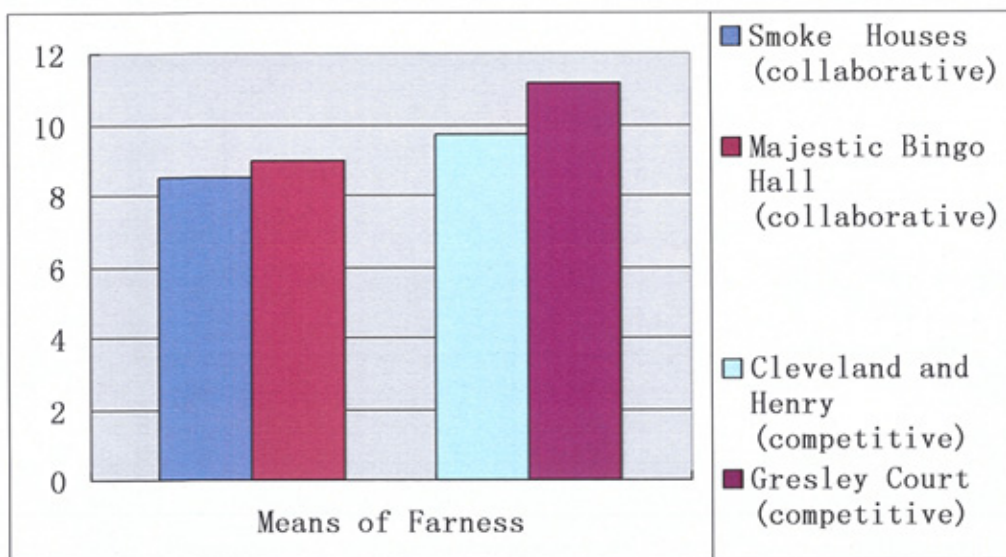
In order to clarify the meaning of this measurement, it is necessary to explain the closeness concept before the comparisons, especially the “farness” concept used here. Freeman (1979) explains the concept of closeness as *“the graph-theoretic distance of a given node to all other nodes. The sum of the rows/columns of the geodesic distance matrix of a graph. Simple closeness is an inverse measure of centrality: the larger the numbers, the more distant an actor is, and the less central. This should really be called “farness”*”.

Thus, “farness” is the sum of the lengths of the geodesics to every other node (i.e. the sum of the distances to every other every other node).

In a diffusion process, a node that has high *closeness centrality* is likely to receive information/infections more quickly than others. Conversely, a node that with *high farness* is likely to receive those more slowly than others.

Projects	Means of Farness
Smoke Houses (collaborative)	8.5
Majestic Bingo Hall (collaborative)	9
Cleveland and Henry (competitive)	9.714
Gresley Court (competitive)	11.143

*Table 11.3 farness comparison of cases*



*Figure 11.5 Farness comparison of cases*

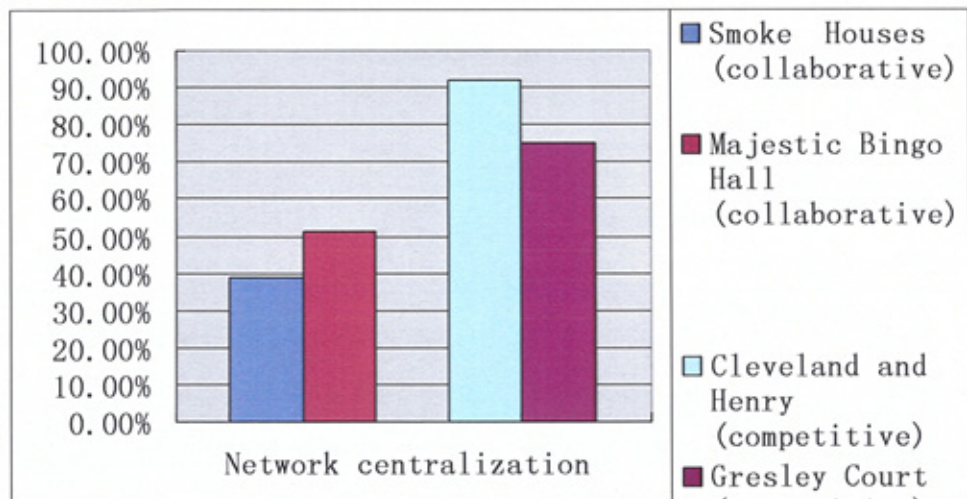
The farness comparison shows that the means of farness in competitive working projects are higher than collaborative ones, though not significantly. This lack of significant difference could be explained by the fact that the network boundaries in this research is relatively small. For networks involving 7 to 9 members, the distance cannot be very far. Therefore, it is necessary to take into account the comparison of



*network centralization.*

Projects	Network centralization
Smoke Houses (collaborative)	39.03%
Majestic Bingo Hall (collaborative)	51.32%
Cleveland and Henry (competitive)	92.00%
Gresley Court (competitive)	75.24%

*Table 11.4 Farness centralization of cases*



*Figure 11.6 Farness centralization of cases*

From the above figures, it is obvious that in competitive working projects the closeness measurement is not equally distributed between all members as the network centralization score is very high, much more than average. For the collaborative working projects, the closeness measurement is equally distributed as their network centralization score is lower or close to average. Considering the network centralization index as means of closeness measurement, it could be concluded that members of competitive working environments needs more time to receive

information and help they need, or indeed, are less likely to receive it

### 11.2.2.3 Flow betweenness centrality

Freeman (1979) explains *betweenness centrality* in the following way:

“Loosely, the number of geodesic paths that pass through a node. The number of “times” that any node needs a given node to reach any node by the shortest path.

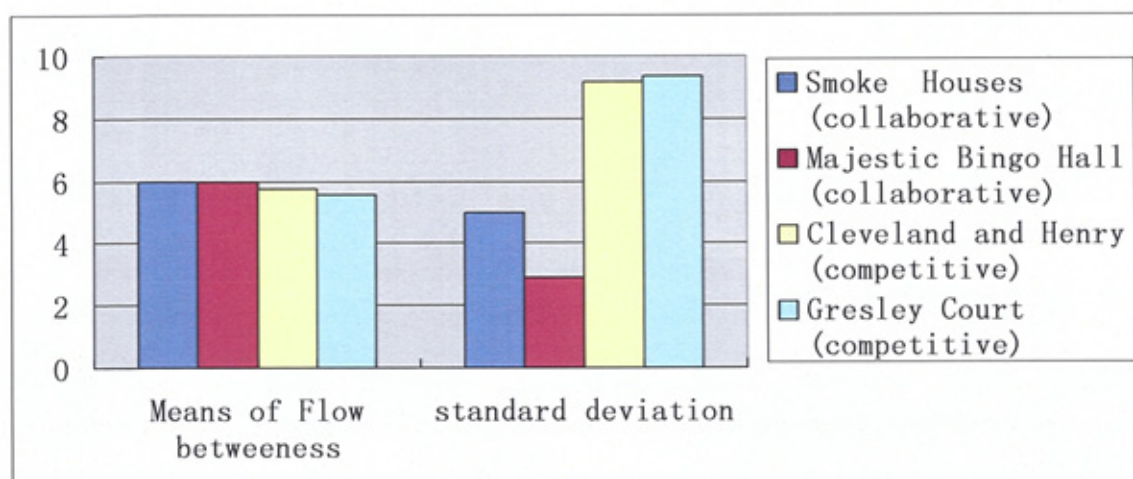
More precisely, if  $g_{ij}$  is the number of geodesic paths from  $i$  to  $j$  and  $g_{ikj}$  is the number of paths from  $i$  to  $j$  that pass through  $k$ , then  $g_{ikj} / g_{ij}$  is the proportion of geodesic paths from  $i$  to  $j$  that pass through  $k$ .”

To put this more simply, *betweenness* is to measure the number of times a node occurs on a geodesic. Therefore, the more times a node appears between the other nodes via their geodesics, the higher *betweenness* measure it scores.

*Flow betweenness* is a concept developed based on betweenness. Suppose that two actors want to have a relationship, but the geodesic path between them is blocked by a reluctant broker. If there exists another pathway, the two actors are likely to use it, even if it is longer and “less efficient.” In general, actors may use all of the pathways connecting them, rather than just geodesic paths. The *flow* approach to centrality expands the notion of *betweenness centrality*. It assumes that actors will use all pathways that connect them, proportionally to the length of the pathways (Hanneman and Mark 2005).

Projects	Means of Flow betweenness	Standard deviation	Network centralization
Smoke Houses (collaborative)	5.969	4.953	11.37%
Majestic Bingo Hall (collaborative)	5.979	2.883	13.21%
Cleveland and Henry (competitive)	5.714	9.192	86.67%
Gresley Court (competitive)	5.571	9.363	83.33%

*Table 11. 5 Flow betweenness centrality of cases*



*Figure 11. 7 Flow betweenness centrality with standard deviation*



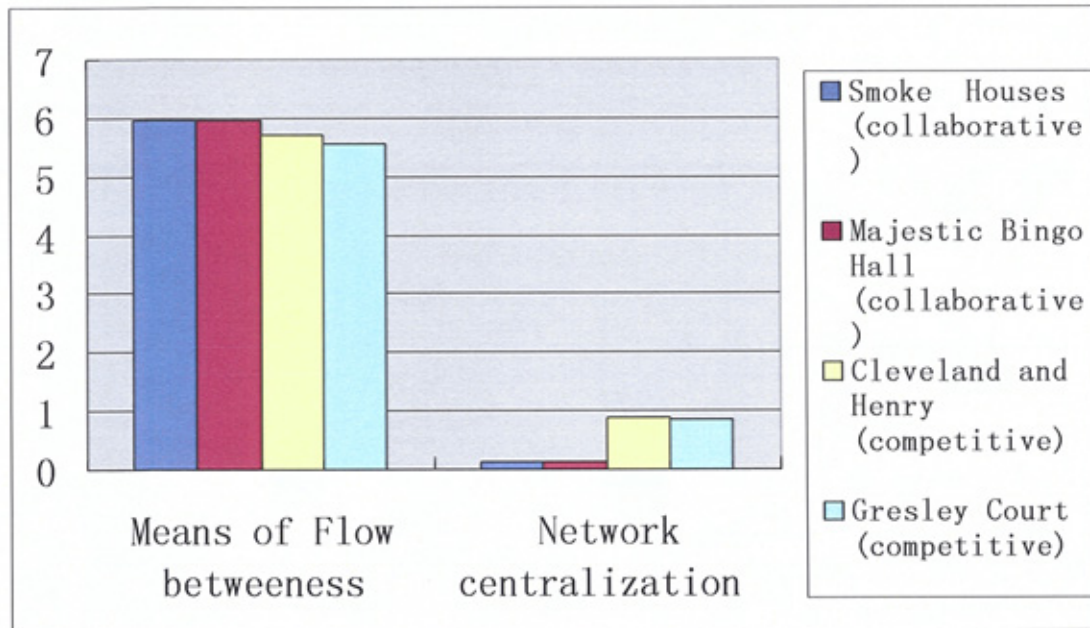


Figure 11. 8 Flow betweenness centrality with network centralization

Because the networks involved in this research were quite small, the *flow betweenness* measurements are not significantly different between the two groups, but a difference did exist. The last two figures consider *means of flow betweenness* along with *standard deviation* and *network centralization*. The standard deviation reveals how tightly all the various examples are clustered around the mean in a set of data and the *network centralization* index is to show how equally *flow betweenness* distributed in all members. Though the *means of flow betweenness* measurement in the collaborative group is just slightly higher than in the competitive group, the *standard deviation* and *network centralization* show that there is not big gap between all members in measuring every organization's *flow betweenness*, all samples are clustered tightly around the means in collaborative group. But in the competitive group, there are big gaps between all individual samples. The *flow betweenness* is unequally distributed in all members. All of these data could be interpreted that in practice, the overall team working pattern is more collaborative in the collaborative group as there are always alternative ties to bridge two members in the network in case one tie fails to deliver information, and the alternative routes are equally distributed between all team members. The overall team working is much more effective in collaborative working

environments.

### 11.2.3 Core/periphery comparison

Core/Periphery Class Memberships:

1: CL CS DA MC SC1 SC2 SC3  
2: SC4

Blocked Adjacency Matrix

		1	2	3	4	5	6	7	8
		C	C	D	M	S	S	S	S
1	CL		1	1	1				
2	CS	1			1	1		1	
3	DA	1	1		1	1		1	
4	MC	1	1	1		1	1	1	
5	SC1	1	1	1	1		1	1	
6	SC2		1	1	1	1		1	
7	SC3			1	1		1		
8	SC4				1	1		1	

Smoke Houses (collaborative)

Core/Periphery Class Memberships:

1: CL DA QS MC SC1 SC2 SC3  
2: SC4

Blocked Adjacency Matrix

		1	2	3	4	5	6	7	8
		C	D	Q	M	S	S	S	S
1	CL			1	1	1			
2	DA			1	1				
3	QS	1			1	1			
4	MC	1	1	1		1	1	1	
5	SC1		1	1	1			1	
6	SC2		1	1	1				
7	SC3		1		1	1	1		
8	SC4			1	1		1		

Majestic Bingo Hall (collaborative)

Core/Periphery Class Memberships:

1: CL DA QS MC SC1 SC2  
2: SC3

Blocked Adjacency Matrix

		1	2	3	4	5	6	7
		C	D	Q	M	S	S	S
1	CL				1			
2	DA				1			
3	QS	1			1			
4	MC		1			1	1	
5	SC1				1			
6	SC2				1			1
7	SC3							

Gresley Court(competitive)

Core/Periphery Class Memberships:

1: CL DA MC SC3  
2: QS SC1 SC2

Blocked Adjacency Matrix

		1	2	4	7	3	5	6
		C	D	M	S	Q	S	S
1	CL			1				
2	DA			1	1			
4	MC	1	1		1		1	1
7	SC3		1	1				
3	QS	1		1				
5	SC1			1				
6	SC2			1				

Cleveland and Henry (competitive)

Figure 11.9 Core/periphery comparison

The *core-periphery structure* is an ideal typical pattern that divides both the rows and the columns into two classes. The core is a high-density block; the other block the



periphery is a low-density block. Actors in the core are able to coordinate their actions; those in the periphery are not. As a consequence, actors in the core are at a structural advantage in exchange relations with actors in the periphery (Hanneman and Mark 2005).

Members in the *core* part have advantageous positions in sending and receiving information; consequently in practice they can receive and provide more knowledge support. In the first group (collaborative working projects) only one member is not included in intensively connected *core* part and this member still have several ties to connect to the *core* part. But in the competitive group, the densities of *core* parts are much lower than the ones in collaborative ones. As in collaborative working environment, most members involved are in the *core* part and the *core* part is intensively networked, the ones not included in the *core* part have several alternative ties connecting to *core* part. Thus, everyone in the collaborative working has advantageous position (or at least no one is in very disadvantageous position) and all members have several alternative ties to connect with other members if one failed to deliver.

### 11.2.4 Density

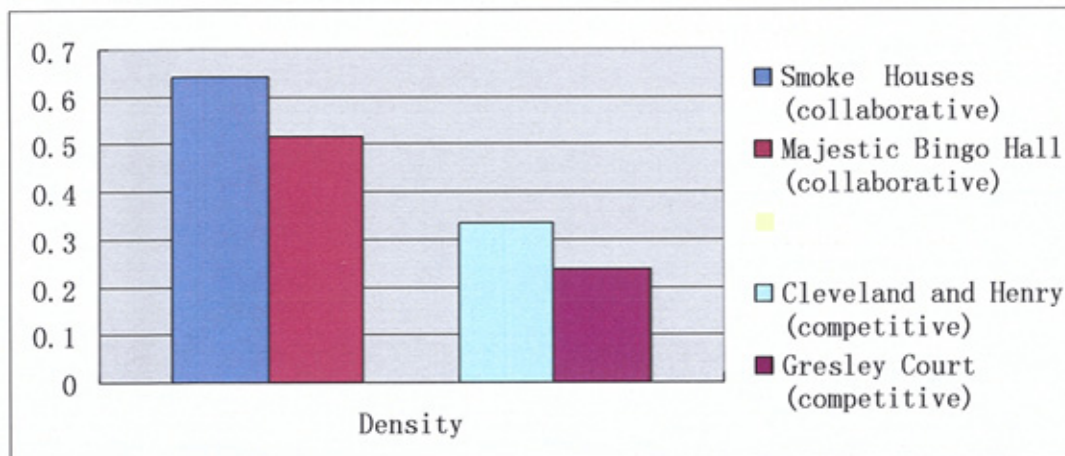
*Density* is a measurement to compare two populations in terms of how intensively members are connected (or not connected).

The density of a binary network (i.e. where values of 0 or 1 are ascribed) is number of actual ties divided by number of possible ties in the network, to show how “dense” the network is. This is to measure overall connections in a network in order to map how intensively all members are connected.

If a relation or tie is "absent" between two nodes in a network, there is a "structural hole" between the two nodes and they cannot exchange (perhaps they are not aware of one another, or there are very high transaction costs involved in forming a tie). As density decreases, more "structural holes" are likely to open in the "social fabric." These holes and how and where they are distributed can be a source of inequality and increase transaction costs (Hanneman and Mark 2005).

Projects	Density
Smoke Houses (collaborative)	0.6429
Majestic Bingo Hall (collaborative)	0.5179
Cleveland and Henry (competitive)	0.3333
Gresley Court (competitive)	0.2381

*Table 11. 6 Density comparison*



*Figure 11.10 Density comparison*

Hanneman and Mark (2005) suggest that the density of a network may give us

insights into such phenomena as the speed at which information diffuses among the nodes, and the extent to which actors have high levels of social capital and/or social constraint. As a key dimension of social networks, *density* measures to what extent social network members reach each other. The higher the density a network has the more transitivity the relations enjoy. The densities of *collaborative group* are higher than average (more than 50 percent of actual ties out of possible ties), suggesting that the collaborative working in collaborative groups is effective and efficient. But in the competitive group, the densities are much lower (about 30 percent of possible ties are connected). Thus, collaborative working in competitive projects is less effective and efficient due to less reachable members.

## Summary

Based on four individual case studies in Chapter 7 to Chapter 10, this chapter compared and analysed the quantitative data collected in previous chapters. As the aim of this research is to compare knowledge supporting activities in collaborative/competitive working environment using a Social Network Analysis approach. Data collected and presented in individual cases cannot be interpreted in a meaningful way without grouping and comparison. Following the pilot study, four projects are presented in formal case studies. Two of them were classified as collaborative working, and the other two competitive. The quantitative data comparisons between the two groups are presented in this chapter in order to draw qualitative conclusion in exploring knowledge supporting activities in two procurement systems.

In the grouping comparison, projects under two collaborative/competitive working conditions are analysed in terms of overall *visualization*, *centralities*, *core/periphery* and *density*. In general, projects under collaborative conditions are more tightly and

intensively connected. Thus, members in collaborative working conditions have more ties and closer connections than those in competitive working environment. These connections bridge “social holes” and therefore result in collaborative working approaches and consequently to better performance.

# Chapter 12 Conclusions: limitations and recommendations

This chapter discusses to what extent the research objectives have been achieved and the methods used to achieve them. A discussion limitations and recommendations for further research are presented at the end of the chapter.

## 12.1 Research rationale review

This section reviews the rationale behind this research, especially the reasons for taking a Social Network Analysis approach.

As discussed in Chapter One, the most value added along supply chains is knowledge rather than physical product. From this viewpoint, collaborative working is, in essence, a knowledge collaboration and integration process.

Academic investigation into Knowledge Management (KM) has evolved from KM *within* organizations to KM *between* organizations. What is increasingly important is the issue of managing collaborative working for knowledge contribution along supply chains.

This research adopts the network analysis approach to analyze knowledge networks under different construction procurement systems, namely, collaborative working and competitive working, in order to compare their differences and provide a means to measure “collaborative advantages”. This research has demonstrated that the patterns of working relationships and knowledge transactions in the two contrasting procurement systems are themselves different.

This research started by reviewing the existing theoretical frameworks and management methods developed in the UK construction industry (which include transaction costs theory, quasi-firm and temporary organization theory, Concurrent Engineering, Supply Chain management and Partnering). Following this, there was a review of Knowledge Management, and finally the rationale for a Social Network Analysis approach was presented.

The UK construction industry has been under pressure to improve its efficiency and performance. Due to its in-built characteristics such as temporary working teams, fragmentation, a changing environment, and so on, not surprisingly, some construction projects fail to achieve their aims (cost control, scheduled programmes, and so forth). Under this pressure for improvement, a number of theoretical frameworks and managerial methods have been developed in order to improve construction project performance. These include transaction cost, quasi-firm/temporary organization, Concurrent Engineering and Supply Chain management and Knowledge Management. The relationships between all participants in construction project have been a focal point in developing these theoretical frameworks and management methods.

All of the theoretical frameworks and management methods discussed above emphasize the importance of committed relationships between all participants in the project process. Thus a Social Network Analysis approach, which is a social science technique designed to analyse a variety of relationships, was considered to be ideal for modelling the knowledge supporting and integration activities in the project process.

In construction projects, transaction costs arise because sometimes participants pursue their own goals rather than the aims of the overall project team. Project management costs are substantially transaction costs, and the aim of project management is to minimize the total of transaction and production costs. Just as bounded rationality and uncertainty/complexity issues arise in the debate of transaction cost theory, the pros

and cons of subcontracting and vertical integration lead to discussions of quasi-firm and temporary organizations. Some firms adopt hierarchical transactions but most rely on market transaction. The concept of the quasi-firm explains this situation: those firms from different organizations behave in a hierarchical organizational form though they are market transactions. A classic example is the relationships between main contractor and a set of sub-contractors.

The conceptualisation of the project organization as a *temporary multi organization* highlights the critical nature of the co-ordination function whilst the transaction cost literature has been concerned with firms and relationships. Mainstream organization theory is based upon the assumption that organizations are, or should be, permanent. Temporary organizational theories are much less prevalent. But in construction projects, the research on temporary organizations needs more attention as this is the basic form for organizing building projects.

Following the need for changes within the construction industry, one particular focus shifted to project processes. Concurrent Engineering is advocated in the construction industry by incorporating aspects of practices to improve project development capability. Concurrent Engineering, also called Simultaneous Engineering, or parallel engineering, is designed to facilitate the simultaneous consideration of all project-related issues and processes from the conception stage to the end. It has the potential to make construction projects less fragmented, improve project quality, reduce project duration, and hence reduce total project cost while creating more satisfied customers; the CE concept emphasizes integration of complementary engineering expertise, cooperation of multiple competing perspectives, communication upstream and downstream product life-cycle concerns, and coordination of group problem-solving activities. Therefore, Concurrent Engineering is regarded as a management approach for overcoming problems caused by fragmentation of the functions of different participants in construction projects. Despite growing interest in the adoption of Concurrent Engineering in the

construction industry, it is general agreed that some implementation efforts have not realised their full potential due to communication barriers in different stages.

Supply Chain management (SCM) in the construction industry was developed at the end of last century. While transaction cost economics mainly focus upon individual contractual relationships, Supply Chain theory aims to analyse interdependent relationships in business process. Supply Chains exist in almost every industry; Supply Chain management in construction aims to integrate a set of practices by managing and coordinating the entire chain from raw materials to end customers. The application of SCM techniques is a means of developing “virtual” vertical integration in the production process - that is to link the process into a chain focussing on maximising the opportunities to add value while minimising total cost. These techniques require a significant shift in the participants toward collaboration, teamwork and mutual benefits. In general, Supply Chain partners integrate more tightly than non-Supply Chain transaction partners. The Supply Chain management approach drives companies to move from traditional open market negotiations to collaborative working, which could be viewed as the foundation of partnering working agreements in the construction industry. In order to implement Supply Chain management successfully, collaboration and teamwork along supply chain are crucial.

All the management methods and theoretical frameworks discussed above are concerned about the relationships between participants. Trust and support, proximity, shared aims, efficient communication and mutual commitment are highly valued for the successful implementation of all these management methods. Partnering and collaborative working finally emerge as a method to integrate all of these key elements. The basis of partnering is a high level of inter-organisational trust and the presence of mutually beneficial goals. The advocates of partnering and collaborative working consider that trust, support and commitment could bring mutual benefits to all participants. These benefits include improved risk control, cost reduction, more efficient working, better performance and satisfied participants as well as the client. In



Egan's two reports (1998, 2002), *trust* is identified a key element of building the integrated project team which is a cure for the fragmentation in the construction industry. This research considers that trust is a foundation for other elements such as support and commitment. Support and commitment are reflections of trust in practice.

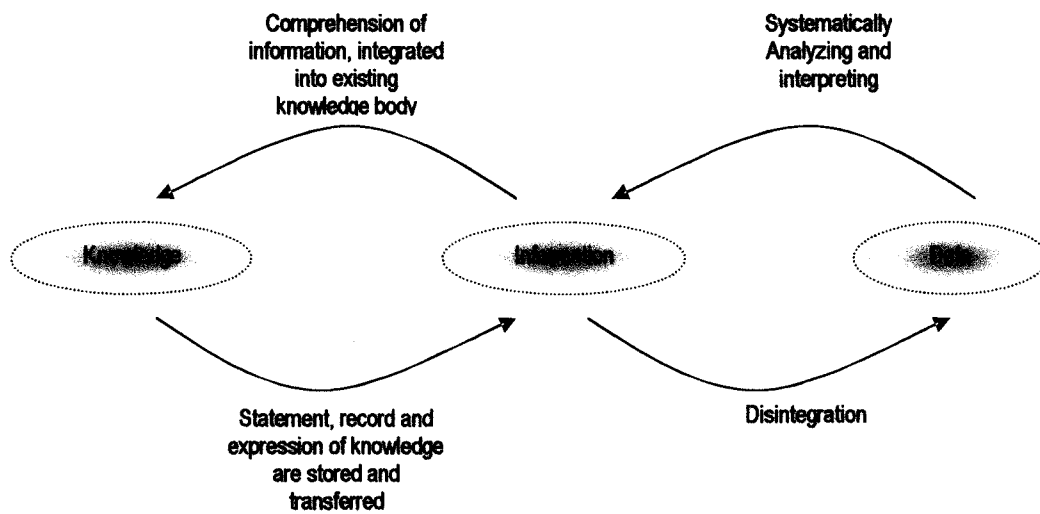
Though these theoretical frameworks have placed a high value of these elements of relationships in order to achieve the management aims successfully, their academic discussion has remained largely in the economic dimension. Social Network Analysis takes the relationship into the broader social context and considers the relationships as business resources such as social capital, which accords high value to the social dimension. This meets the challenges of Knowledge Management as the main difficulties of Knowledge Management reside its social and tacit dimension.

Following Latham's (1994) and Egan's (1998) reports, the construction industry in the UK has been in transition to overcome its perceived performance problems. Knowledge and learning have been regarded as core competence for construction industry in order to improve overall performance. The first challenge for organizations is how to capture and reuse knowledge in the turbulent project environment. Few however, have investigated how to manage knowledge across organizational boundaries (such as in quasi-firm environments) toward overall project performance, or manage knowledge along supply chains and supply networks. The reason that most literature has concentrated on Knowledge Management research *within* individual organizations is that people view knowledge as a vital resource and an organizational asset. But the shared aims and constraints in the construction project environment need knowledge integration and support *across* organizational boundaries. Therefore, this research moves the focus of Knowledge Management from managing knowledge *within* individual organization towards *between* organizations.

Tacitness is a key element to distinguish knowledge from data and information, when

we talk about Knowledge Management, the most important thing is to manage the tacitness of knowledge, otherwise we are managing data or information. Information technology can help but cannot complete Knowledge Management process, due to this tacit dimension. Some firms have invested heavily in the information system infrastructure but there are no confirmed measurements about how this has helped and improved overall performance. Some of the Knowledge Management investments based on information management are not broadly used in practice. Therefore, this research proposed its own working definition based on review and discussion of the definitions of three terms, data, information and Knowledge Management in order to distinguish the different management methods for further research.

As all of discussions and definitions are based on one presumption - that information is transferred to knowledge once relevant information is integrated into existing knowledge body and this is a one-way transformation - this research considers the process of transferring information into knowledge takes several steps and the transforming processes are two-ways, this is to say, knowledge could be transferred as information as well as information could be transferred into knowledge. The transforming process varies according to environment and background of every individual. This research developed the following model to consider the transformation process in knowledge.

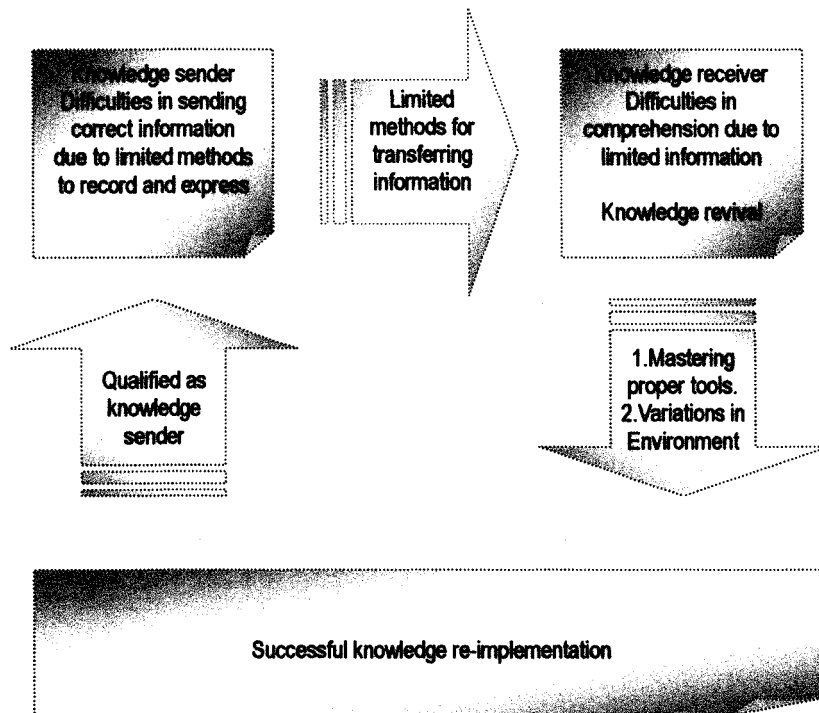


This diagram adopts flat structure rather than hierarchical structure because of two reasons:

Firstly, all authors using hierarchical structures presume that data is converted into information and consequently information is converted into knowledge. They consider the conversion process is one way but this structure considers this is a two way process. Secondly, they presume that information is superior to data and knowledge is superior to information in hierarchical structure.

In the framework adopted in the current research, knowledge is transformed back into information before it is delivered to the recipients, which means, knowledge is transferred as meaningful information rather than knowledge itself, when it is recorded, stored, and expressed by all means. The delivered information becomes knowledge only when the recipient has deep understanding of the information and could use the relevant information to solve some particular problems.

The difficulties in transferring knowledge are presented below following the definition and explanations above.



This model also could be used to explain that why some of firms have started Knowledge Management initiatives but have stopped at information management stage due to the difficulties in transferring knowledge. In fact, all existing frameworks of Knowledge Management in construction industry pay attention to the IT element, failing to take into account of the tacit and social dimensions in Knowledge Management. They have tended to regard these issues as peripheral rather than the most critical issues, which will lead to Knowledge Management failure if not managed properly. From the viewpoint of this research, these are two critical issues to distinguish information management and Knowledge Management in practice.

Though Knowledge Management is regarded as a vital resource for the improvement and numerous efforts to improve Knowledge Management, the difficulties in managing knowledge still remain. Besides, the complexity of technology is increasing and fragmentation along technology clusters is becoming unavoidable. Therefore, *know-who* is becoming more important than *know-how* in practice as this is the quickest solution in a fast developing technology environment.

To summarize, most modern management methods in construction value the relationships between all parties involved in project process. Trust, proximity and information flow based on close relationships are regarded as critical issues to reduce transaction costs and to assist the implementation of Concurrent Engineering and Supply Chain management. In today's transition to partnering procurement systems, these issues are highly valued. Also, as discussed above, the social and tacit dimensions in Knowledge Management draw attention to relationship between parties involved, and the fast growing diversity of technology leads to fragmentation along technology clusters. *Know-who* is becoming more important than *know-how* in finding a solution under time constraints. All these management approaches face limitations by isolating organizations from their tightly connected contexts. Though they all appreciate the importance of relationships, these theoretical frameworks still focus on the economics dimension in analyzing business activities. Social Network Analysis takes one step further to consider these connections as social capital and provides an approach to value the social dimension of the relationships.

Committed relationships embedded in a firm's networks are very important, and these relationships should be viewed as valuable resources which can lead to competitive advantage. When such relationships in networks are perceived as valuable resources, social capital emerges as a suitable concept to deal with various relations and activities. Therefore, a social network approach is introduced in this research as a useful theoretical framework and a means of analysis for knowledge integration and support activities in the construction process.

Network perspectives enable the analysis of organizational behaviour beyond its boundaries, especially in a social context. Social Network Analysis has been used previously for analysing organizational behaviour, but on work has, to date, focused on its benefits for analysing knowledge integration in projects. The present research explored the potential for doing so, and particularly uses Social Network Analysis to highlight the differences between knowledge integration in collaborative and

competitive project environments.

All management theory used in construction projects take committed relationships as the critical issue, which leading trust, proximity and promoting overall project performance. Little or no work has been done on benchmarking the development of committed relationships against the overall project performance. The complexity of measurement is the main difficulty for benchmarking how committed relationship promotes overall project performance. This research has visualized informal relationships and attempted to benchmark how committed relationships promote knowledge integration using quantitative data. Social Network Analysis was used as an important analysis tool for this benchmarking process.

## **12.2 Aim and objectives considered**

A previous section has presented the research rationale in general, and this section presents how the research was developed in detail (research aim, objectives, research strategy and relevant data collection to support them).

Based on the general research direction and rationale, the following aim and objectives were developed, and the research methodology and detailed data collection methods were designed for the empirical study of these.

The aim of this research was to compare knowledge integration structure and process in two different working environments: namely, a collaborative environment and a more traditional, competitive one.

In order to achieve this aim, the research work used a Social Network approach. From this research aim, an assumption is that there are a virtual knowledge supporting

networks in the construction process. This point has been confirmed by the case studies presented.

Accordingly, the objectives set in Chapter one have been achieved, since the study has:

- Described the present application of Social Network Theory to competitive/collaborative working and Knowledge Management in a construction project context.
- Compared different social network structures within two different procurement systems, (competitive and collaborative) as to what extent and measures these two systems differ. This research demonstrated that a project with a collaborative partnering relationship creates very different networks structures from a non-partnering one, in terms of their knowledge integration process. This point was support by quantitative data measurements developed from Social Network Analysis. Centralities, density and core/periphery measurements were used to explain different knowledge transaction activities in project process. The comparison displayed that collaborative working results in collaborative advantages in terms of knowledge integration.
- Investigated knowledge integration network features in two procurement systems from a Social Network Analysis perspective. This has been achieved by combination and analysis of the quantitative data.
- Mapped existing pathways and patterns for knowledge flow between organisations in collaborative/competitive working projects.

With quantitative data drawn from Social Network Analysis studies, this research presented a number of case studies. Following one pilot study which tested and refined the data collection routine, four cases are presented. Within the four cases, two cases adopted collaborative procurement systems (one overall partnering and one project partnering), the other two adopted competitive procurement. The virtual knowledge supporting networks from the two procurement systems were analysed and

presented using Social Network Analysis software. The virtual knowledge supporting networks were compared in the data analysis chapter and positively confirmed the differences. Due to different working patterns in two procurement systems, the knowledge supporting networks are significantly different from a Social Network Analysis point of view. Compared with competitive working cases, almost all organizations involved in collaborative working cases, showed an intensity of virtual network that was much higher in core/periphery parties in the knowledge contribution and support process. The advantages of collaborative working are shown by the working patterns comparison, collaborative working promotes trust and committed relationships, which lead to knowledge integration in an informal way, that is to say, in a informal relationship not based on contractual commitment. The committed relationships in collaborative working connect all organizations tightly and intensively in knowledge supporting virtual network. The conclusions and findings could accelerate collaborative working manners by clarify potential benefits and drive the reinvention of construction industry.

## **12.3 Discussion**

From the discussions above, the following recommendations to people in academia and practice could be concluded, and the limitations of the present study can also be viewed as considerations for further research.

### **12.3.1 Recommendations and contribution to knowledge**

The author considers that a major contribution to knowledge has been made by this work, not least in the distinctive research method. The use of Social Network Analysis has previously been limited. The full potential of this technique in construction



management research has not so far been explored in this field. This thesis shows how Social Network Analysis can be used descriptively, i.e. to represent knowledge integration in projects. It is also possible for Social Network Analysis to be used as a modelling tool for unproven knowledge management process and products in collaborative projects.

Apart from this methodological consideration, several recommendations flow from the research.

#### *Recommendation 1*

The research conclusion suggests that though committed relationships have been highly valued in the development of construction project management, the focus should shift from its largely economic dimension to a more social dimension. This viewpoint contributes to considerations of business networks and social capital, which provides more valuable approaches and a wider spectrum of thinking about business internal resources and external environments, and leads to new business solutions in certain context.

#### *Recommendation 2*

Knowledge has been preserved as the vital resource, more important than other resources such as land and capital. But managing knowledge has been experienced numerous difficulties. This research concludes that one big obstacle in managing knowledge effectively is ignorance of the differences between information and knowledge. Though they are easy to differentiate in discussion, people still make mistakes by trying to manage information when they intended to manage knowledge. This research considers that Knowledge Management failures stem from the neglect of two essential dimensions of knowledge: tacit and social dimensions. That is the reason some firms have invested heavily in IT hardware and software, claiming they

are managing knowledge effectively but eventually stopped at the information management stage. Knowledge management is about people and action, not information transfer efficiency.

#### *Recommendation 3*

The virtual knowledge supporting and integration networks in construction project process have been made more “visible” by the Social Network Analysis approach in this research. Although the focal point is professional knowledge flow rather than material flow along supply chains, it can be suggested that Supply Chain and Supply Network Management reconsider the key management methods and Critical Success Factors in managing effectively. Also the Social Network Analysis approach pushes *people* to the forefront in valuing their supply relationships in a social context.

#### *Recommendation 4*

This research explains *why* and *how* partnering and collaborative working brings certain advantages. From the Social Network Analysis viewpoint, social connections are considered as *power* in network interactions. The improvements in overall connections promote effectiveness and efficiency in network scale working. This research also suggests a useful benchmarking tool to measure some elements which was considered hard to measure such as *support* and *committed relationships*. This benchmarking method can also be used in similar research and practice.

#### *Recommendation 5*

The network perspective for research and management has not, until now, been fully explored. As reviewed in this thesis, most previous management methods and theoretical frameworks face limitations by isolating organizations from their tightly connected context. This is partly because the boundaries of networks are difficult to

determine in organizational management and blurred boundaries are constructed socially by the network members. Social Network Analysis can also take into account informal working relationships, which are constructed differently from formal organizational regimes. This can be used to explain something that cannot be explained through formal working relationships, such as when an individual's influence arises not from formal designation.

### **12.3.2 Limitations and further research**

The limitations of this research mainly come from the empirical cases studied. In order to investigate the specified problems that arise in practice, the empirical study limited itself to the focused objectives and research aim via certain research design and data collection routines.

All five cases were based in the Northeast of England; three projects are from North Tyneside Council and two are from the Esh group. Some geographical characteristics may have influenced the outcomes of the research, but these have not been considered at the present time.

Secondly, due to the research scale, personality attributes were not considered. Social Network Analysis focuses on relationships rather than individual attributes, but personal attributes undeniably influence relationships and consequently this could have influenced the outcomes of working patterns.

Thirdly, this research focused on individual (cross-sectional) examples of the Variation / Change Order process alone, as the experimental focus of study. Due to time constraints, other potential knowledge transfer episodes were not included, and there was no time for longitudinal examination of relationships evolving in dynamic

environments.

Fourthly, all cases adopted in this research were fairly small projects. The number of organizations involved was consequently less than would have been the case with larger projects. Thus the interviews merely involved the site managers who had a thorough understanding of the whole project process. In bigger projects, the bureaucratic arrangements would have required more interviews to integrate different viewpoints in establishing the working relationship connections by Social Network Analysis.

Participants' social contacts outside the work situation were not taken into account, and social integration has not been examined to any great extent. These may influence working relationships and patterns considerably.

Finally, the results of this research are indicative of associations and trends within the data and do not imply any causal relationship between social network structure and management efficiency. Further research using large scale comparisons or/and longitude scales would be needed to confirm this, and further test the value of the methodologies and research results.

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# Appendix A: Cover letter for information access



Dear Sir / Madam:

I am a PhD candidate conducting a research study which focuses on knowledge sharing and contribution between parties on projects when they are confronted by design changes. The purpose of this research is to compare the knowledge contribution patterns between project parties in competitive/collaborative working relationships.

I am seeking your help by requesting access to one or more of your projects. The research will involve asking a number of participants questions which will enable me to fill in a very short form. It should only take about 20 minutes of each respondent's time. Names and results will remain confidential and identities and responses will not be disclosed to anyone without your agreement.

If you have any questions regarding this study, please contact me by any means you prefer.

Sincerely

Ximing RUAN

School of the Built Environment, Northumbria University

Email: [ximing.ruan@nunn.ac.uk](mailto:ximing.ruan@nunn.ac.uk)

Telephone: 0191 2437695

Fax: 0191 2273167



# Appendix B: Social network data collection questionnaire



Postal address:  
X Ruan, A201, Ellison Building, School of the Built Environment, Northumbria University, NE1 8ST  
Email address: ximing.uan@unn.ac.uk Mobile number: 0785 5763610

Project Title

Please check the box to indicate that your consent to participate in the research ☐ I agree

Date

Location

Name

Position

Organization

There are three categories listed below (1) people you need their knowledge and expertise (2) people need your knowledge and expertise (3) people you discussed with but don't fall into the last two categories.

Please identify people within this project but from other organizations that you contact when trying to find a solution. It doesn't matter if the solution is adopted or not finally.

The situation we are looking at is when you have already started on site and you are now faced with a design change

please check the box of organizations' name whose member of staff meet the description

People you  
needed their  
knowledge  
and expertise

a company

☐

b company

☐

c company

☐

d company

☐

e company

☐

**People who  
need your  
knowledge  
and expertise**

company list like previous section

People you  
discussed but  
dont fall into  
the last two  
catogories

company list like previous section

record of open  
discussion

# Appendix C: Data collection meeting record form



## Data collection meeting record form

Meeting description

Date  Time

Location

Participants:

name/position/organization

name/position/organization

name/position/organization

name/position/organization

name/position/organization

name/position/organization

name/position/organization

name/position/organization

name/position/organization

name/position/organization

name/position/organization

name/position/organization

**Notes**

**Meeting record**

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# Appendix A: Cover letter for information access



Dear Sir / Madam:

I am a PhD candidate conducting a research study which focuses on knowledge sharing and contribution between parties on projects when they are confronted by design changes. The purpose of this research is to compare the knowledge contribution patterns between project parties in competitive/collaborative working relationships.

I am seeking your help by requesting access to one or more of your projects. The research will involve asking a number of participants questions which will enable me to fill in a very short form. It should only take about 20 minutes of each respondent's time. Names and results will remain confidential and identities and responses will not be disclosed to anyone without your agreement.

If you have any questions regarding this study, please contact me by any means you prefer.

Sincerely

Ximing RUAN

School of the Built Environment, Northumbria University

Email: [ximing.ruan@nunn.ac.uk](mailto:ximing.ruan@nunn.ac.uk)

Telephone: 0191 2437695

Fax: 0191 2273167

# Appendix B: Social network data collection questionnaire



School of the Built Environment

Postal address:

X Ruan, A201, Ellison Building, School of the Built Environment, Northumbria University., NE1 8ST

Email address: ximing.ruangunn.ac.uk Mobile number: 0785 5763610

Project Title

Please check the box to indicate that your consent to participate in the research

☐

I agree

Date

Location

Name

Position

Organization

There are three categories listed below (1) people you need their knowledge and expertise (2) people need your knowledge and expertise (3) people you discussed with but don't fall into the last two categories.

Please identify people within this project but from other organizations that you contact when trying to find a solution. It doesn't matter if the solution is adopted or not finally.

The situation we are looking at is when you have already started on site and you are now faced with a design change

please check the box of organizations' name whose member of staff meet the description

People you needed their knowledge and expertise

a company

☐

b company

☐

c company

☐

d company

☐

e company

☐

company list like previous section

People who  
need your  
knowledge  
and expertise

company list like previous section

People you  
discussed but  
dont fall into  
the last two  
catogories

record of open  
discussion

# Appendix C: Data collection meeting record form



## Data collection meeting record form

Meeting description | \_\_\_\_\_

| \_\_\_\_\_

Date | \_\_\_\_\_ Time | \_\_\_\_\_

Location | \_\_\_\_\_

Participants:

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

name/position/organization | \_\_\_\_\_

**Notes**

**Meeting record**